FARM BULLETIN No. 6

THE MANGO in india

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

NEW DELHI

This is the sixth of a series of bulletins planned by the Indian Council of Agricultural Research to meet the paucity of literature in a simple, yet authoritative form and dealing with farming and animal husbandry subjects. Each of the Bulletins is so written as to give a general picture of farming practices in vogue in the country, and suggest improvements based on research results. The Bulletins, it is hoped, will be found useful by the farmer, the agricultural student and the Extension worker alike.

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A profusely bearing Langra tree in Pepsu

Photo: Agricultural Department, Pepsu

THE MANGO IN INDIA

THE mango is the most ancient among the tropical fruits indigenous to India. Few other tropical fruits have the historic background that the mango has and few others are so intimately connected with Indian folk-lore. It is the most popular and the choicest fruit of India and easily occupies a prominent place among the best fruits of the world. The ripe mango is exceedingly refreshing to eat and is an excellent source of vitamins A and C. The fruit is also used in various ways even when it is immature and green, viz., in curries, pickles, preserves and chutneys. Ripe mango slices and pulp can be preserved and canned for use when fresh fruit is out of season. The mango is cultivated all over India and occupies about 60 per cent of the total area under fruits.

CLIMATE

The mango tree grows well in humid as well as dry climates obtaining in different parts of India. However, it blossoms and fruits better in the dry regions where there is good rainfall for four months from June to September, followed by a period of dry and rainless weather for eight months. It does not thrive well in the humid zones of Bengal, Assam, Travancore-Cochin and the Tamilnad in the extreme south-east of Madras where the climate is wet and moist for over eight months in the year.

Rain, fog or cloudy weather at the time of flowering from November to February prevents the setting of fruits and favours the development of pests and diseases. On the other hand, the regions of rainless weather during the periods of flowering and maturing of the fruit are known to yield the most healthy crops. The total amount of rainfall is not so important as the season in which it occurs. Where a mild, cool and dry season prevails during the normal flowering period of the mango, good yields can be expected.

The mango does not thrive in the hills of the Punjab, PEPSU and Uttar Pradesh and the temperate regions of Himachal Pradesh and Kashmir above elevations of 3,000 feet. Even below 3,000 feet, young trees may be killed by frost and older trees may have their twigs destroyed. The Indo-Gangetic plains of the eastern Punjab and Uttar Pradesh, and the States of Rajasthan and Vindhya Pradesh are less frequented by cold waves of long duration and are, therefore, suitable for the growing of the mango, although, when young, the trees have to be sheltered against winter frost.

Summer temperatures ranging from 115° to 120°F accompanied by strong winds, such as those experienced in most parts of North and Central India, may occasionally cause sun-burn on the fruit. Under these conditions, it is necessary to plant a high and strong wind-break, preferably of *shisham* trees (*Dalbergia sissoo*), on the south-west of the plantation.

The greater part of the peninsular India comprising the States of Bombay, Saurashtra, Hyderabad, Mysore, Madras, Rayalaseema and the Circars of Andhra and Madhya Pradesh is well adapted to the growing of mangoes. The whole of Bihar and the adjoining territories of West Bengal and Orissa are equally well suited to the cultivation of mangoes.

SOILS

The mango develops a deep and widely spread root system, covering a great expanse of land. It requires a very deep but well drained soil in which its roots can get abundant space to forage and develop normally. In India, some of the best mango groves are to be found on the great Gangetic plains of North India and also on the banks of the great rivers of the peninsular India, where the soil is a rich, alluvial loam of great depth.

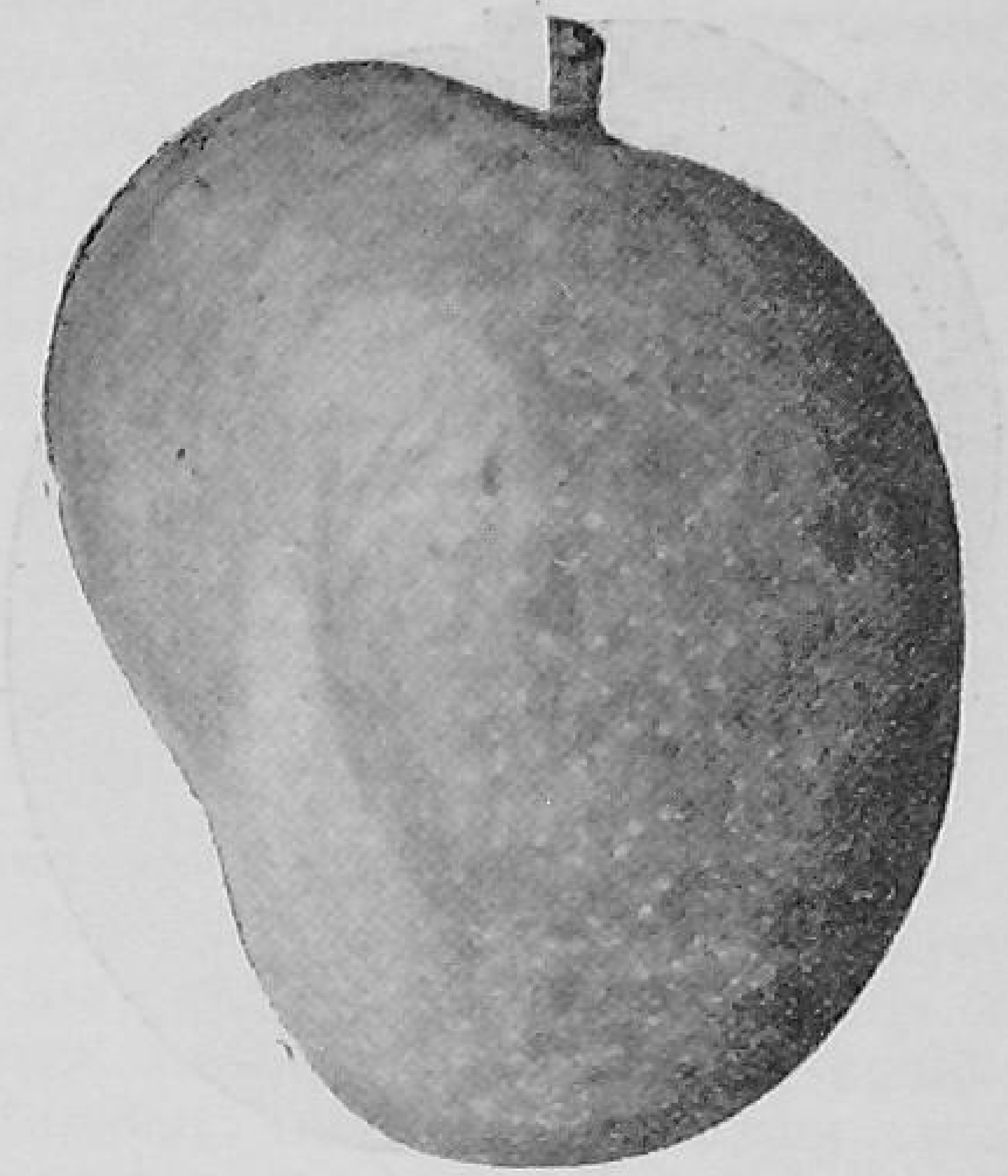
The difficulty about the proper soil depth for the mango frequently arises in the mountainous regions of western and South India. In these tracts, trees planted in five feet deep, loamy, medium black soil overlying a *murum* substratum have given excellent results. The minimum depth of soil in which fairly good results can be expected is three feet.

In selecting the soil, the subsoil also has to be taken into account. The mango will not thrive in a soil with a subsoil of hard rock or of limy, yellow, sticky clay. The roots of full-grown trees penetrate deeply, and if they encounter such impervious strata they soon suffer from ill health.

Highly calcareous soils containing large quantities of lime nodules are considered too poor for growing the mango. Such soils are highly alkaline and burn the young plants soon after planting. The finely textured, deep black cotton soils which become sticky on wetting and crack heavily during the hot weather are also not suitable. They retain more water than is necessary and become water-logged. As a result, the roots rot due to lack of air and eventually the tree dies.

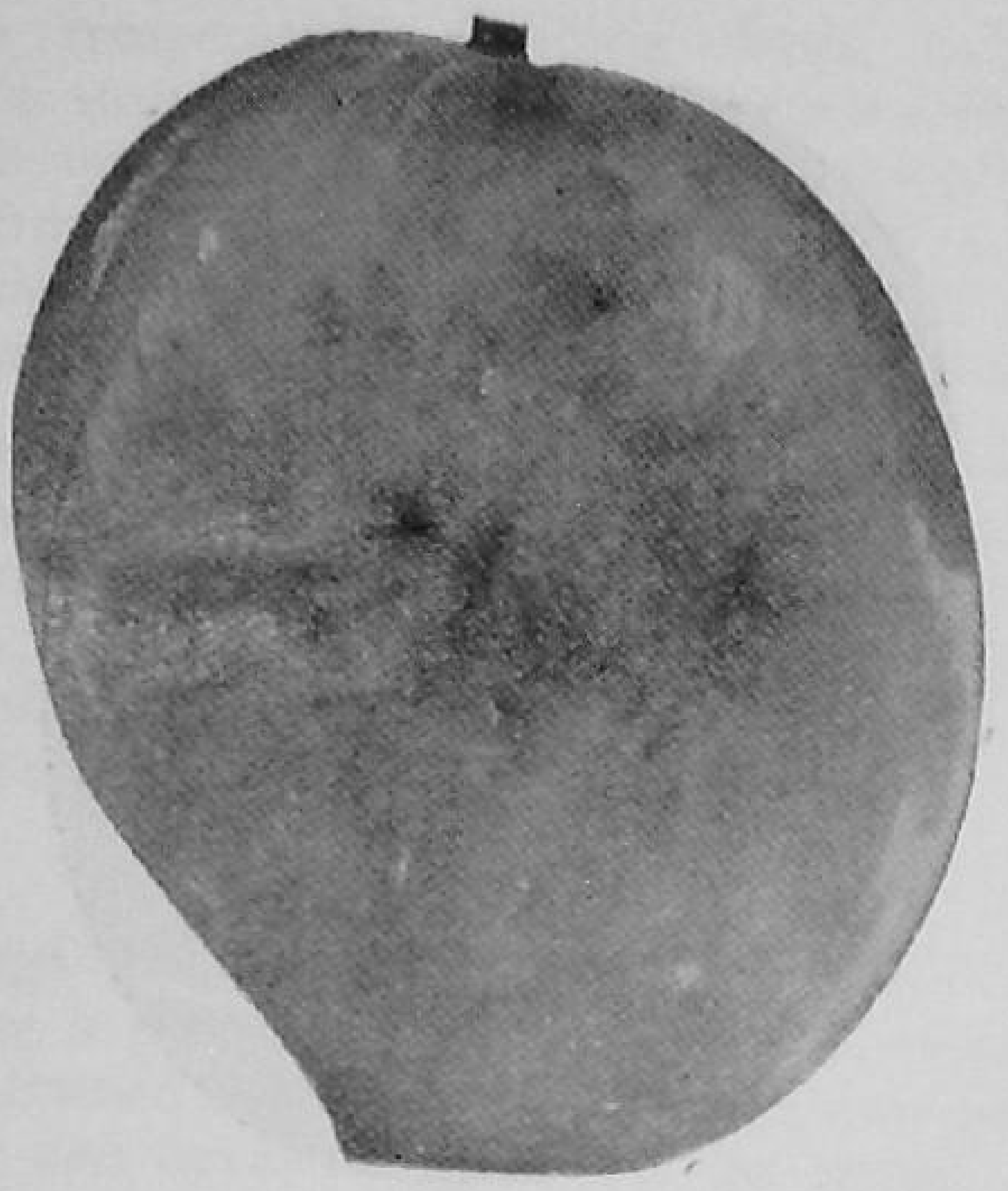
VARIETIES

For successful mango-growing it is necessary that the varieties planted in a commercial orchard are productive, of good quality and adaptable to the climate of the tract. Different varieties are suited for growing in different climatic



Alphonso

Aman Dasheri



Pairi

Bangalora (Totapuri)

conditions. For example, the *Alphonso* mango which is so well adapted to the coastal tracts of Bombay State does not grow so well in the interior parts of India. Such is also the fate of many Central and North Indian varieties when planted in the more tropical parts of South India and *vice versa.* However, it is not always true that a variety from a particular region when grown in another far away region will not flourish. It is only by trying a variety in different climatic zones of the country that the grower can ascertain its adaptability. For instance, *Alphonso* and *Pairi* of Bombay are grown in many parts of South India with fair success. Similarly, *Langra* of Uttar Pradesh is growing well on the banks of the Narbuda in Gujerat.

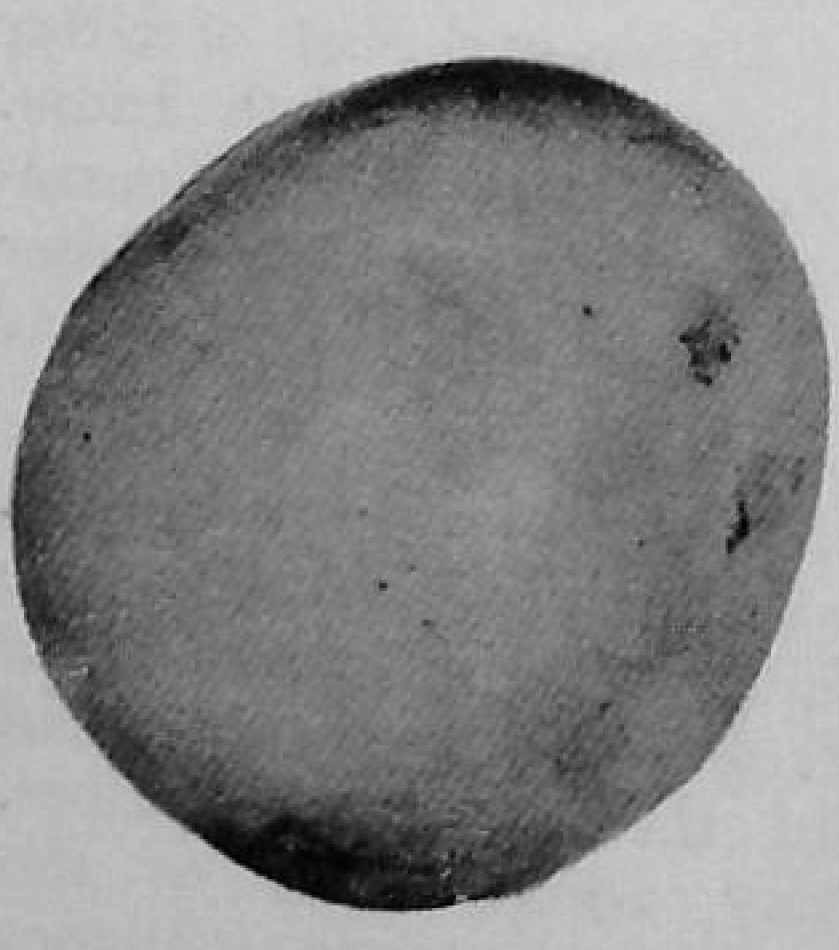
The number of varieties grown in India is very large. Each variety has its own peculiar taste, flavour and consistency of pulp for which it is liked by a section of the populace. A dessert mango suitable for large trade should possess a pleasant, sweet, luscious, sub-acid, appetizing taste and a good flavour. The seed must be small and the pulp firm, abundant and free from fibre. After picking, the fruit must ripen slow y, develop an attractive colour and keep long in storage. Soft,l stringy, sour varieties with turpentine flavour are considered inferior as table fruit and are used for pickling and other culinary purposes. On the other hand, some varieties, though of soft pulp, fibrous and of low keeping quality, are reputed for their thin, sweet juice and are in great demand in the local markets all over India.

Of the several hundred named varieties grown in different parts of India, many have been grown from seed and as such have no standing as standard varieties in the interprovincial markets. They are grown locally on a small scale in each state to meet the tastes and needs of the local population. The famous dessert mangoes of India known for their excellent eating qualities are *Alphonso* and *Pairi* of Bombay, *Fernandin* and *Mankurad* of Goa, *Langra*, *Lucknow Safeda*, *Safeda No. 1*, *Dasheri*, *Khajri*, *Samar Bahesht Chausa*, *Malda*, and *Fazli* of Uttar Pradesh, and *Himauddin* and *Alampur Benishan* of South India. Out of these, *Alphonso* and *Langra* are the chief leading varieties of the western and north-eastern India, respectively. Other important dessert mangoes cultivated commercially in Bihar are *Bombai*, *Zardalu* and *Sepia*.

Alphonso is the mango *par excellence* of western India. It is grown on a large scale in Ratnagiri and Bulsar on the West Coast. It keeps in good condition for nearly three weeks from the date of picking. It is successfully shipped in cold storage to Great Britain and is sold there at fancy prices. It is also used for canning in Bombay where some of the largest canning factories of India are located to can mangoes for supply to the Army and for export abroad. *Pairi* is another

Langra

Dalimbya



Romani

leading variety of Bombay State and is extensively cultivated all over the Deccan plains east of the Western Ghats.

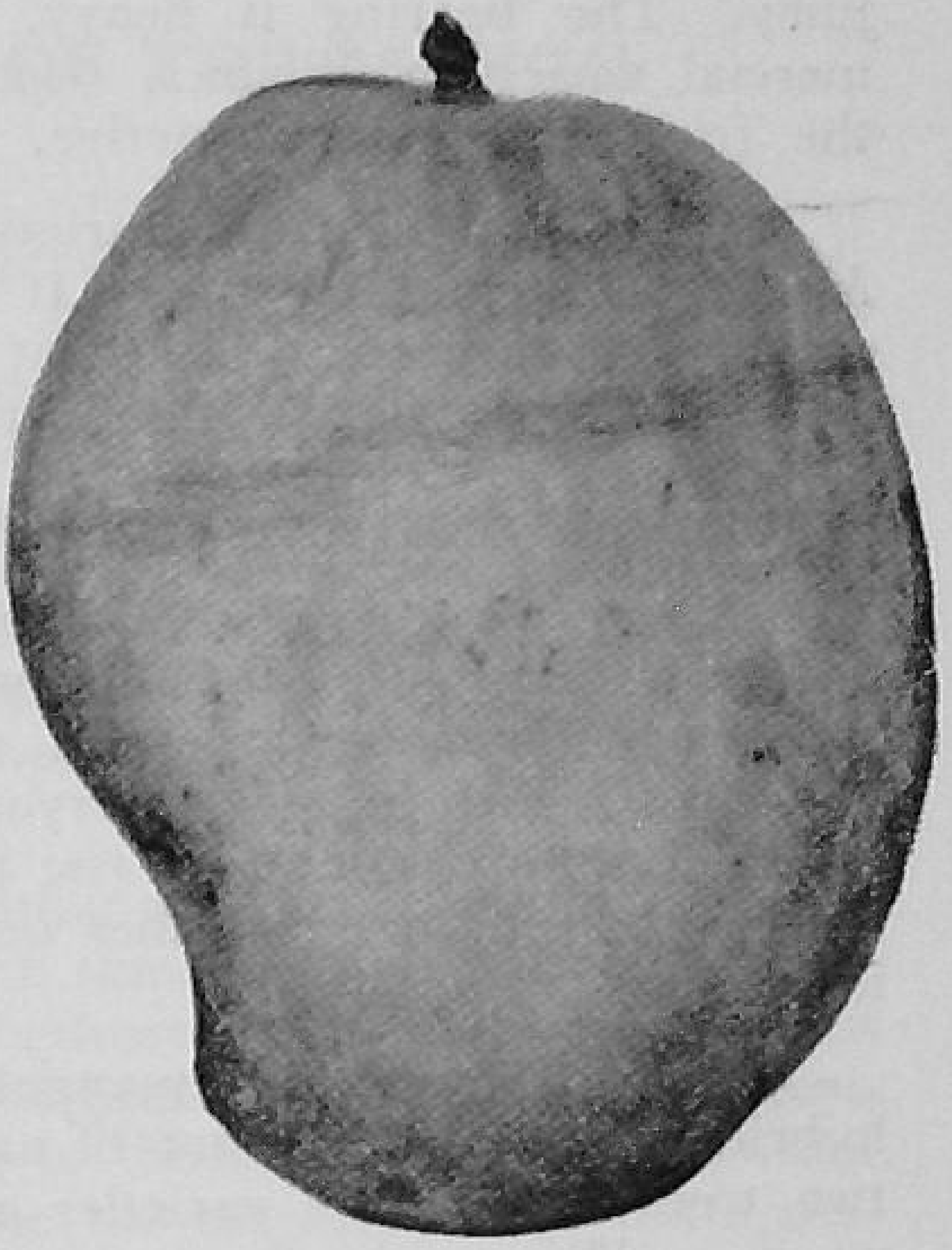
Bangalora (known as *Totapuri* in the Bombay market), *Neelam* and *Romani* of South India, though rather inferior in taste and flavour to the above-mentioned dessert varieties, are well known for their heavy cropping, excellent keeping quality and abundance of fibreless but hard pulp. These varieties are extensively cultivated in Rayalaseema and the Circars of Andhra and in many other parts of South India, for export to Bombay and North India in the months of May, June and July.

Suvaranrekha and *Banganpalle* are very popular table varieties of the Circars and Rayalaseema. *Jamadar* and *Salebhai-ni-Amdi* are the choice mangoes of Saurashtra, and *Mulgoa* is the reputed variety of Hyderabad-Deccan. *Shendriya* is locally famous in Poona and *Rajapuri* is the well-known juicy mango of Gujerat. *Borsha* has long been known as the select mango of East Khandesh and *Dalimbya* is an attractive dessert variety of South Gujerat.

Kavasji Patel of Bombay and *Mulgoa* of South India are fruits of very large size and are utilized in Bombay State for making preserves. *Hathi-Jhool* of Uttar Pradesh and *Jehangir* of Madras are well known for their big size as well as for good eating qualities. Accordingly, they are used for dessert purposes as well as for making preserves. All these large-sized varieties are unfortunately shy bearers.

Langra is a popular and standard variety of Uttar Pradesh

Nilam



Rajapuri

and Bihar. It bears heavily but rather irregularly. The colour of the skin tends to remain green. The pulp is creamy, juicy, plentiful and fibreless. The stone is thin. However, *Dasheri* is gaining popularity in Uttar Pradesh and the Punjab. The fruit is elongated and thin. The pulp is fibreless, juicy and sweet. The flavour is delicate and excellent. It also keeps well and fetches the highest price in the North Indian markets. *Bombay Green* (*Malda*) is the standard early variety of Uttar Pradesh. It has good quality. The flavour is rather strong. *Samar-Behisht Chausa* is a late variety of excellent quality. However, it bears very irregularly. Another good commercial variety of Uttar Pradesh is *Fajri Zafrani*, which is an excellent table fruit. The new varieties of Uttar Pradesh are *Rataul* and *Taimuriya*.

Apart from *Langra*, another good variety grown in Bihar is *Zardalu*. It originated in Bengal but has established itself in Bihar. It has excellent quality and bears moderately to heavily. The fruit is oblong with cadmium yellow colour. It has moderate juice. Another outstanding variety of Bihar is *Gulab Khas*. Some people feel that it has an aroma like the rose. It sells at a premium in the market. The fruit which is oblong-oblique with very attractive colour is rather small in size. The flavour is very pleasant and sweet and it is rather

juicy. The bearing is heavy. Another well-known commercial variety of Bihar is *Gopal Bhog*. It bears heavily but the fruit is not so attractive.

In West Bengal, the variety *Bombai* which is locally called *Malda* is very successful. It gives heavy yields and is economical to grow. The fruit is of medium size and the flesh is firm, fibreless and moderately sweet.

MONOEMBRYONIC AND POLYEMBRYONIC MANGOES

There are two distinct races of mango—monoembryonic and polyembryonic. In monoembryonic mangoes, the seed contains only one embryo and, therefore, it gives rise to only one plant. But in polyembryonic types, the seed contains several embryos which give rise to several plants which can be separated from one another on germination and planted as independent plants.

In monoembryonic mangoes, the embryo is generally a hybrid, being the product of natural crossing of the flowers of two trees of different varieties growing in the same environment. The seed of a monoembryonic mango, therefore, gives rise to a plant which shows mixed characteristics of two different kinds and does not look like the parent tree from which the seed is obtained. In other words, monoembryonic mangoes when grown from seed do not usually breed true to type.

On the other hand, in polyembryonic mangoes, out of several embryos in the seed only one embryo may be produced by the crossing of flowers of two different varieties. All the rest are vegetative growths of the ovule tissue of the female parent, that is, they are part and parcel of the vegetative tissues of the parent tree and, therefore, do not contain the element of any other variety. Even the one plant which is expected to be a product of sexual process is often suppressed and absent. In the circumstances, the seed of a polyembryonic mango when sown gives rise to several plants which breed true to the parent.

In India, almost all the varieties of mango are monoembryonic and, therefore, when grown from seed do not breed true to their parents. In the circumstances, they have to be propagated by vegetative methods. The polyembryonic types are not to be found in any part of India, except in Malabar where a few varieties belonging to this class are found. *Olour* is the famous polyembryonic mango of Malabar which is propagated from seed.

It is interesting to note that polyembryonic mangoes abound in the moist tropics of South-East Asia, such as Malaya, the Philippines and Indonesia.

PROPAGATION OF THE MANGO

LIKE many other fruit trees the mango has been propagated in the tropics principally from seed. Not only a tree grown from seed takes a number of years to reach its full stature for bearing fruit, but it also shows the influence of a mixed parentage and the fruit of the offspring varies a good deal in shape and quality from that of the parent tree. Therefore, in order to ensure early bearing, productiveness, uniformity and parent quality in the progeny, it is necessary to propagate the superior varieties of mango by a vegetative method of propagation known as grafting.

Grafting is the art of uniting a branch of one tree to the seedling stem of another of the same family which will afterwards nourish it. The union between the two is brought about by joining the cut surface of the branch of the tree to be propagated with a similar surface of the seedling stem of another tree in conditions which cause the cut surfaces to unite permanently. The branch of the superior variety so joined is called the scion, the seedling stem on which it is grafted is called the stock, and the new plant thus prepared by combining the stock and scion is called the graft. The actual joining between the stock and scion takes place at a soft region between the bark and wood called the cambium.

INARCHING OR GRAFTING BY SIMPLE APPROACH

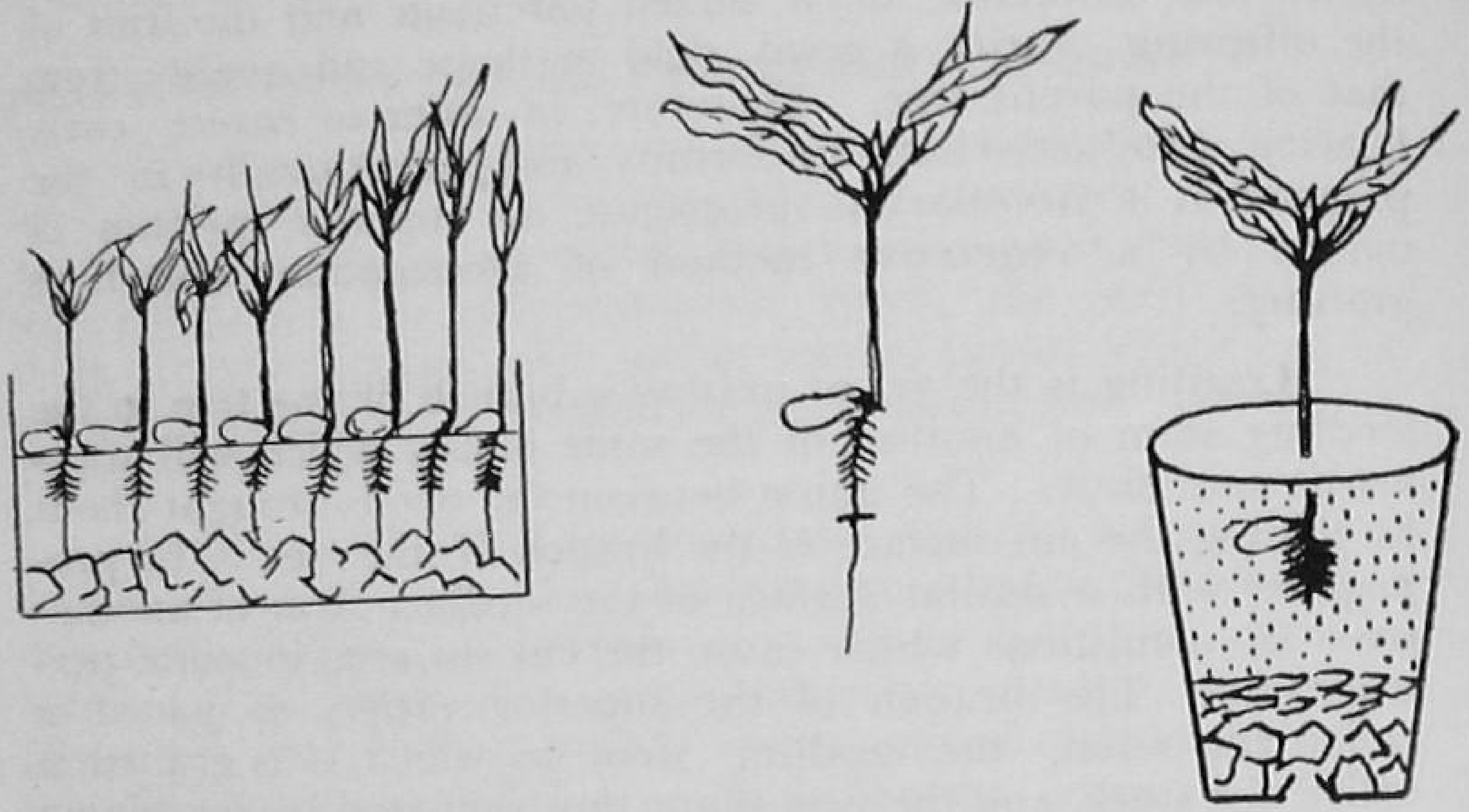
The method of grafting called inarching or simple approach is universally practised by nurserymen all over India for preparing potted mango grafts.

In this method, the stock plant is grown from seed of any country mango and the branch of the scion tree is grafted onto it while it is still attached to its parent. After the union takes place between the two, the head of the stock above the graft-joint is cut off and the scion is separated from its parent a little below the graft-joint.

The first point to be considered is the preparation of stock plants in handy earthenware or bamboo pots. The usual practice is to collect stones (seeds) of mixed varieties of mango from the streets and wayside places in the consuming centres during the harvest season and sow them directly in pots. The practice often gives unsatisfactory results.

To ensure healthy, quick-growing stocks which would attain the size for grafting in the shortest time possible, it is desirable that the fruits of a selected country mango tree known for producing vigorous seedlings are collected and their seeds extracted for growing stocks. It may not, however, be

possible for every nurseryman to own such a parent stock tree of known quality. Therefore, it is advisable to sort out good, plump, healthy, full stones from any mixed lot and sow them, first in a small bed, and then after about two months, transplant the most vigorous of the seedlings in pots.



A—Mango seeds are germinated in a sunken bed filled with leaf mould ; B—vigorous mango seedling is selected and its tap-root trimmed (at mark), keeping fibrous roots intact ; C—the pot is filled and the seedling transplanted

Mango seeds lose their germinating power within 20 to 30 days. It is always wise, therefore, to sow them as soon as they are extracted from ripe fruits. Prepare a small, sunken bed about a foot deep. Put gravel at the bottom and then fill it with plenty of leaf mould (manure made by rotting dry leaves) to a depth of about six inches. Arrange a large number of seeds in a single layer over the surface of the bed and cover the seeds with four inches of leaf mould; keep the bed continuously moist. The seeds will germinate within 15 to 20 days, and a month later, when the first reddish leaves have turned ripe green, the seedlings will be ready for lifting.

By this arrangement, the tap-root is turned aside when it touches the layer of gravel, and fibrous roots are freely and profusely developed on it nearer the root collar. The young plants may be gently pulled out from the leaf mould,

with the stone still attached to the plant, without causing the least injury to the root. Out of the many seedlings grown in the bed, only the most vigorous ones with straight stems and plenty of fibrous roots are lifted and transplanted in earthenware or bamboo pots about five inches wide and nine inches deep.

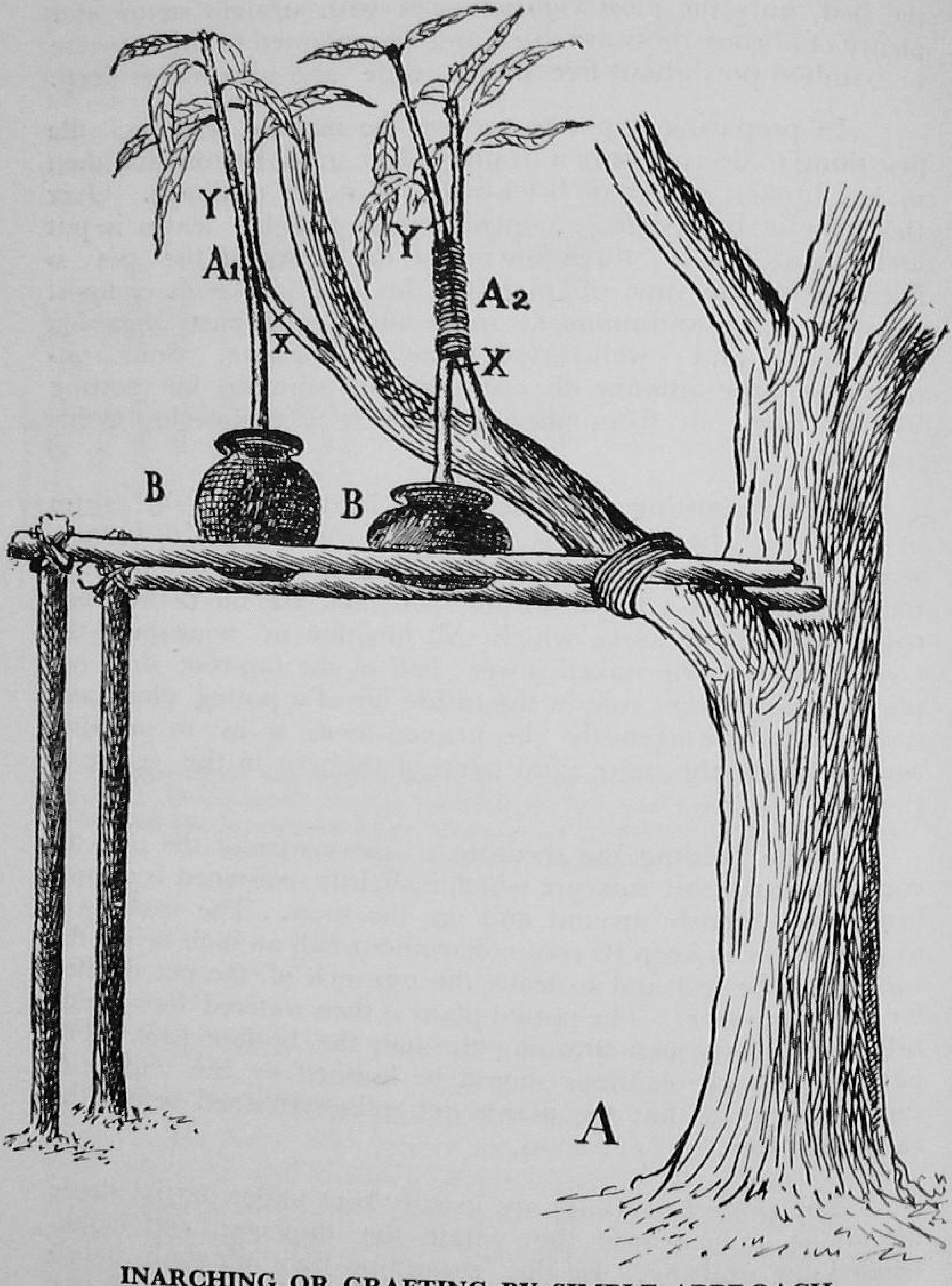
In preparing a pot to receive the mango seedling, the first thing to do is to bore a drainage hole in its bottom and then to put broken pieces of brick-bats in it for drainage. Over the layer of brick-bats, a small quantity of dry leaves is put and then finally three-fourths of the depth of the pot is filled up at the time of planting the seedling, with compost (mixture of soil and manures) made out of equal parts of garden soil (loam) and well-rotted farmyard manure. Soils containing a large amount of clay are not suitable for potting but silt dug out from the river banks is admirable for this purpose.

While planting, the seedling is held erect in the centre of the pot. The most vital part of the root that is to be preserved in transplanting the seedling is the first half of the tap-root which bears a lot of fibrous roots, and also the fleshy green cotyledons in the stone which still function in nourishing the young plant. The naked lower half of the tap-root does not play any important role in the future life of a potted plant and it should advantageously be pruned away so as to properly accommodate the more vital parts of the root in the centre of the pot.

While holding the seedling in the centre of the pot, the compost or the soil mixture which is slightly moistened is pressed firmly but gently around and on the roots. The seedling is so planted as to keep its root collar about half an inch below the surface of the soil and to leave the top inch of the pot unfilled for holding water. The potted plant is then watered thoroughly till the water is seen draining through the bottom hole. The potting of stock seedlings should be finished by the middle of the monsoon so that the plants get well-established before the rains are over.

The potted seedlings are usually kept under partial shade for about a year until they attain the thickness and height needed for grafting. In the meantime they are daily hand-watered by means of a watering can with a fine rose. Water should be gently given so as not to wash out the soil from the pot. Once or twice a month, the soil in the pot should be stirred to prevent it from packing, and if the topsoil has been washed out, it should be replenished by adding a handful of fresh compost.

Age of the stock for inarching. Although a well-established potted stock seedling can be inarched at any age, it has



INARCHING OR GRAFTING BY SIMPLE APPROACH

A—scion tree ; B—potted stock seedlings elevated on a scaffolding to meet the scion branches ; A1—the stock operated and contacted with the scion branch ; A2—the graft after bandaging ; X—the point at which the scion will be severed from the parent tree; Y—the point at which the stock will be topped after the graft is ready

been found more practicable to inarch the seedlings when they are about one year old and have attained a height of about $1\frac{1}{2}$ feet and thickness ranging from $\frac{1}{4}$ to $\frac{1}{2}$ inch.

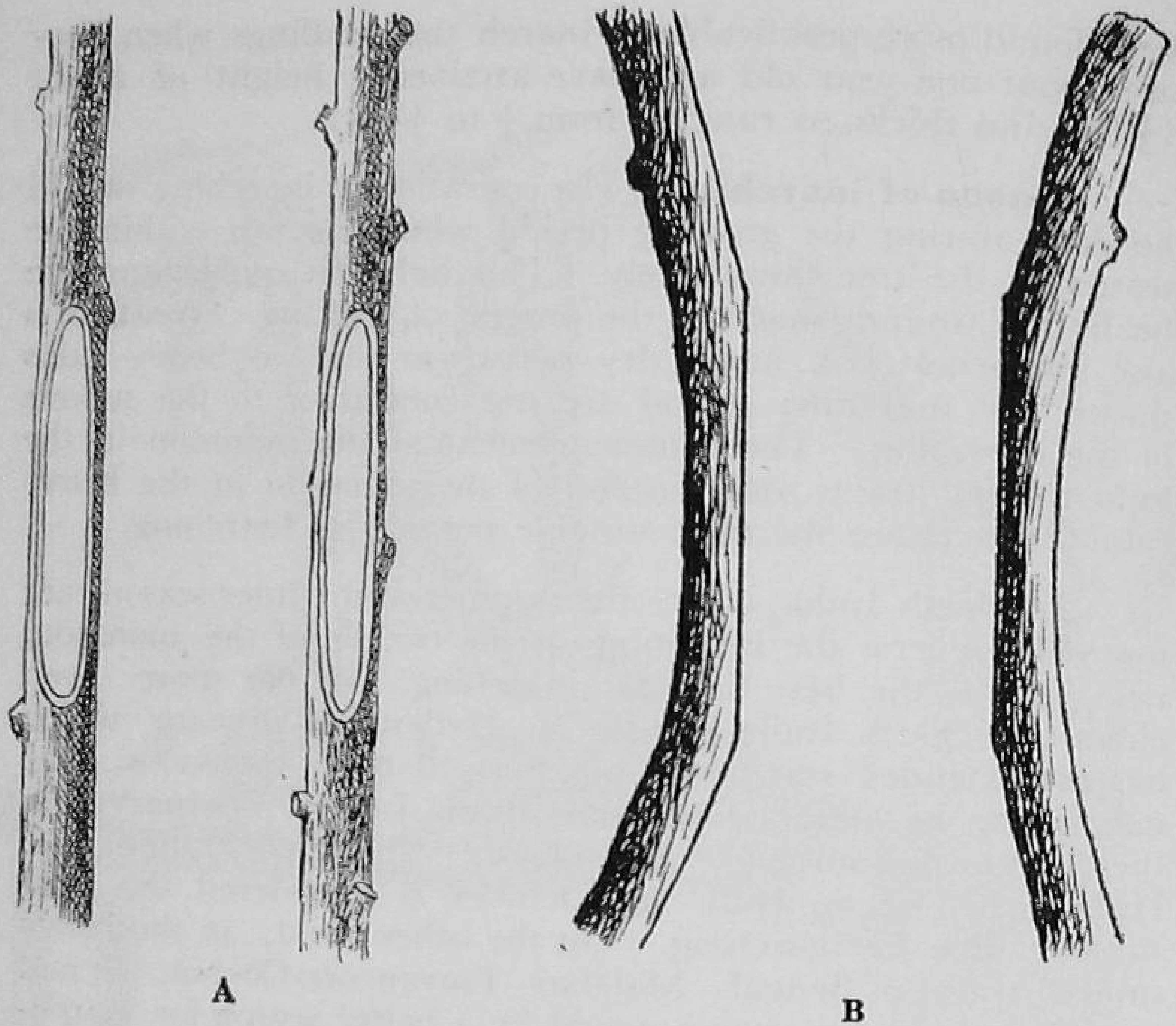
Season of inarching. The operation of inarching should be done during the growing period when the sap within the tissues of the tree flows freely. This helps in quickening the healing of wounds made in the process of grafting. Weather is also important. A hot, dry period as well as heavy rains during the inarching period are not conducive to the success of the operation. The commencement of the monsoon in the light rainfall tracts and the end of the monsoon in the heavy rainfall tracts are the most suitable periods for inarching.

In North India, where the summer and winter seasons are markedly severe, the beginning or the middle of the monsoon, i.e, July is the best time for inarching. In the more even climate of South India south of Hyderabad-Deccan, which has an extended rainy season due to two monsoons, the mango can be inarched any time from July to February. In the States of Bombay, Saurashtra, Madhya Pradesh and Hyderabad-Deccan, July to October is considered the most suitable time for inarching. On the other hand, in the heavy rainfall tracts of Bengal, Malabar, Travancore-Cochin, the end of the south-west monsoon would be a better season for inarching the mango.

The operation of inarching. The potted stock seedlings of the proper size are carried near the scion tree and elevated on a scaffolding to meet the scion branches. A suitable scion branch has to be found for each individual stock.

Generally, a one-year old terminal twig of the scion tree, about two feet in length, is chosen for grafting. The thickness of the scion branch should be very nearly the same as that of the stock. In the course of the operation, the scion branch is first bent downwards and then upwards like an arch and made to approach the potted stock plant which has been raised on a platform to the level of the scion. The stock and the scion are now operated at the place where they closely touch each other.

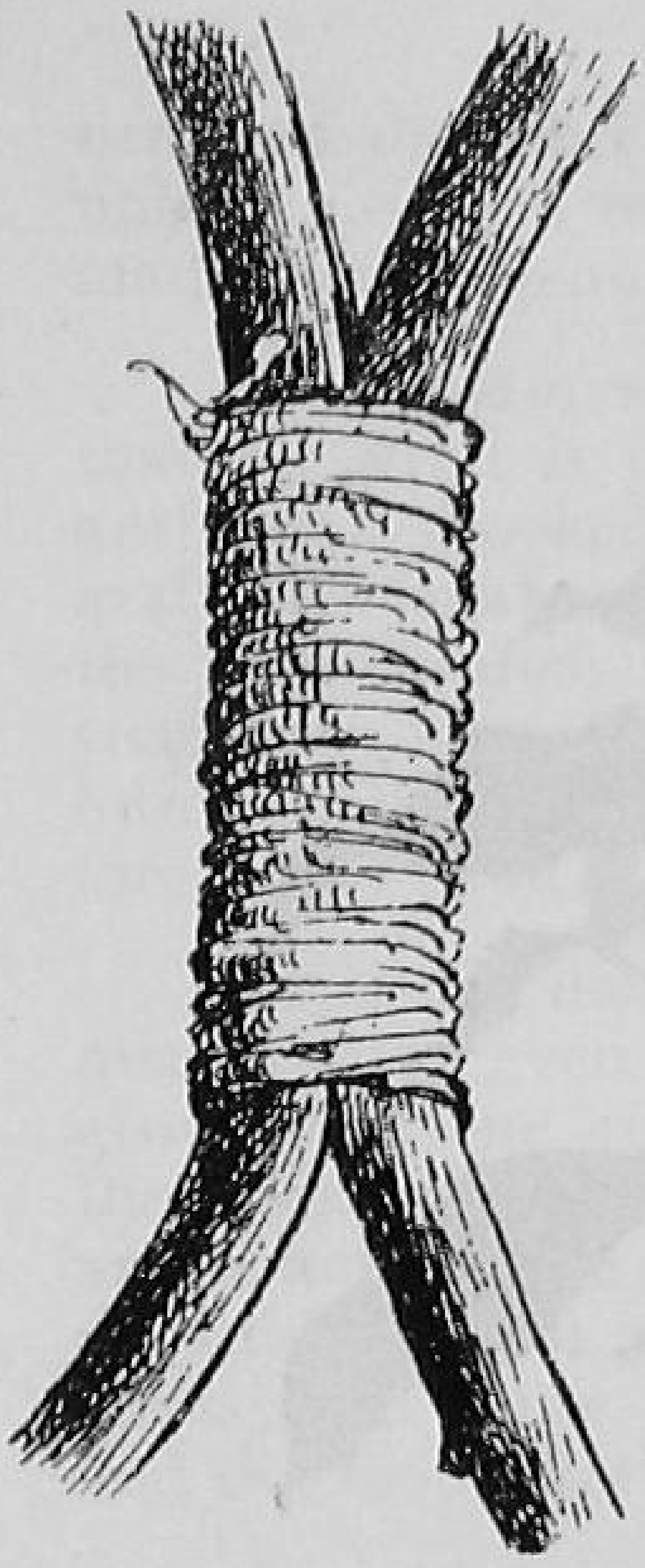
A thin slice of bark and wood, about two inches long, nearly $\frac{1}{4}$ to $\frac{1}{3}$ inch broad and $\frac{1}{12}$ inch deep, is removed by means of a sharp grafting knife from the stem of the stock as well as from the scion branch. These dimensions of the cut are for a branch which ranges from $\frac{1}{4}$ to $\frac{1}{2}$ inch in thickness. Therefore, the dimensions should be proportionately increased or decreased according to the thickness of the particular stock and scion branches which are to be operated. The cuts thus taken on each partner should be absolutely flat, clean, even and smooth. The ends of the cuts should be sloping and not angular.



THE OPERATION OF INARCHING : Cuts on the stock and scion (A—front view and B—side view)

The cut surfaces of the stock and scion are made to coincide face to face so precisely as not to allow any hollow space between them, and are tightly tied, first with a flat tape made from the banana leaf sheath and then with a jute string. Finally, the bandage is made water and airproof by covering it with grafting wax or a paste made by mixing cow-dung and clay. While the pots containing the stocks are on the scion tree and the union is going on, water should be given to the pots daily so as to keep the soil moist.

After about two months when the stock and scion will have united, the scion branch is severed from its parent tree by cutting it through below the graft-joint. The severance of the scion from its parent is effected slowly. First, a shallow cut is made ; after about a fortnight, it is deepened half way through the thickness of the branch ; the scion is completely severed after another fortnight. The original top of the stock above the graft-joint is then removed. The graft thus prepared



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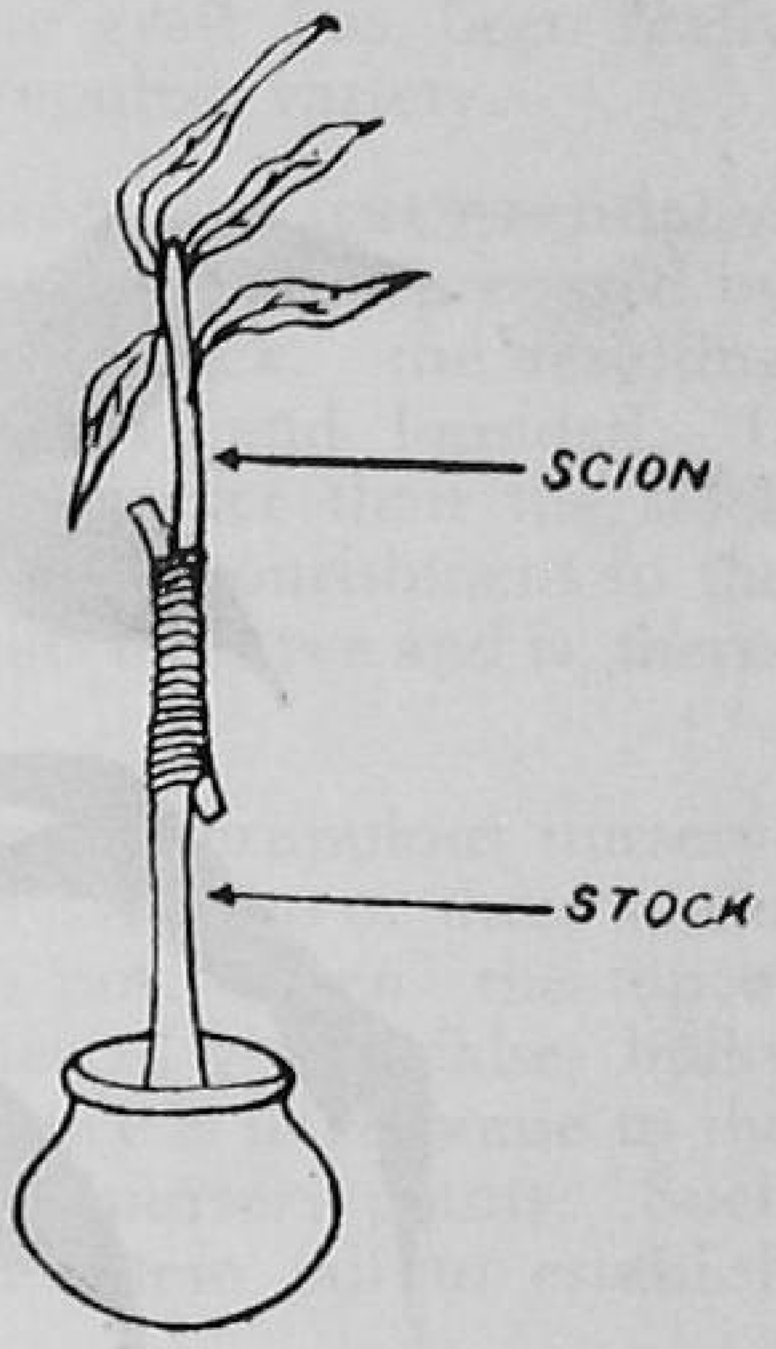


D

C—stock and scion united and bandaged; D—inarch-graft after separation from the scion tree

is now taken to a shaded place where it is nursed, hardened and cared for forabout six months before it becomes fit for planting in the field.

Generally, it is not necessary for the grower to learn the operation and technique of grafting, as potted mango grafts are prepared and sold by nurserymen who are skilled in this line. It is, however, absolutely necessary for the grower to learn to distinguish a good graft from a bad one. At the time of purchasing a mango graft from a nurseryman, the grower should see that (1) the graft has both its scion and stock stems of equal thinckness (the scion may be a little thinner, but should never be thicker than the stock); (2) the scion is growing straight with plenty of broad, dark green, healthy leaves ; (3) the union between the stock and scion has perfectly healed so as not to present any hollow or unfilled space between the two stems ; (4) the union is made at least six inches above the root collar of the stock and not lower ; (5) the string or tape has not deeply cut into the

When purchasing inarch-grafts from the nurserymen select such as this

tissues of the graft-joint ; (6) the top of the stock above the union has been removed ; and (7) the graft has been really made from a genuine scion tree of a reputed variety.

To obtain well-shaped mango trees, the first essential is that the graft is properly made. If it has been prepared by grafting a crooked scion branch on the stock, the resulting graft will make the future tree crooked and lopsided. If the scion branch is disproportionately thicker than the stock stem, the latter is unable to give sufficient nourishment to the former and the resulting graft soon begins to starve and is, therefore, short-lived.

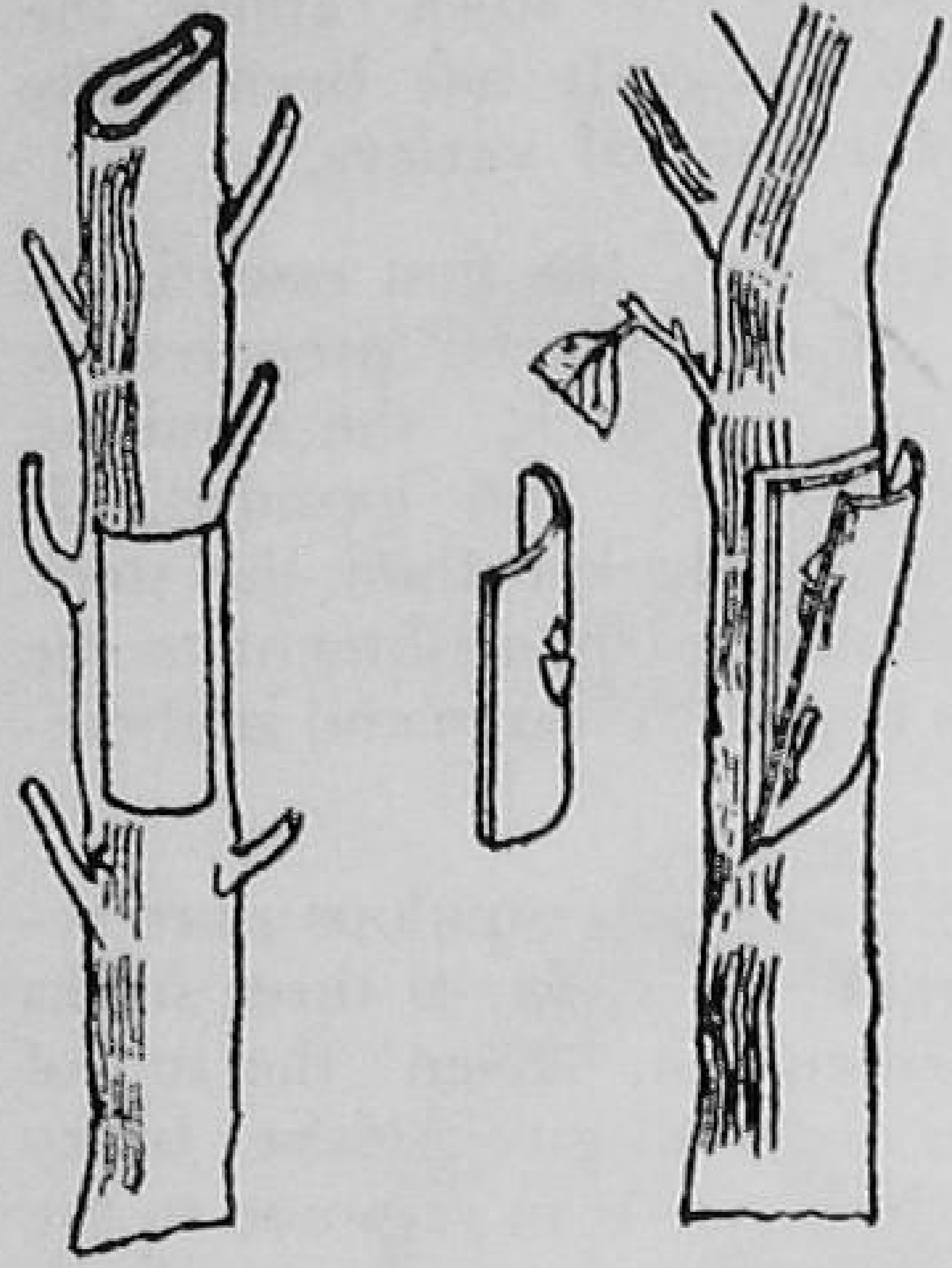
It is not uncommon to find some unscrupulous nurserymen grafting even a huge scion branch over two or three stocks growing in one and the same earthen pot. Even the top of the stock plant is not removed in order to give a false bulky appearance to the graft. This malpractice is in response to the demand by most growers for very large nursery plants. Such grafts with huge tops and poor root system fail to establish and die soon after planting.

Inarching is very expensive and laborious as grafts have to be hand-watered and nursed for over two years in earthen pots. Besides, this method is only possible where the scion tree is growing near the pot nursery of the stock seedlings. A cheaper, easier and more efficient method of propagation called budding has lately been adopted to prepare mango grafts.

BUDDING

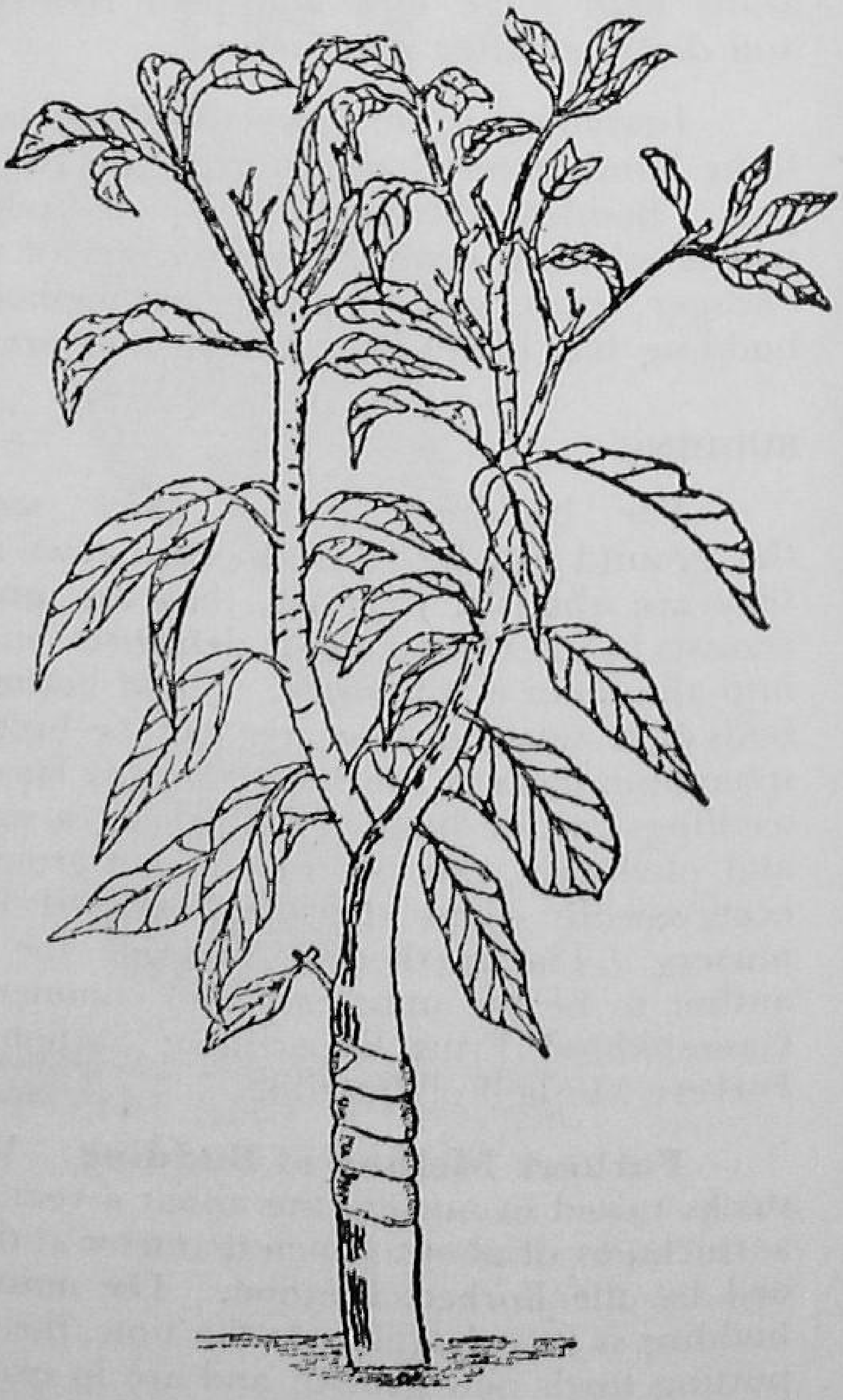
For budding, mango stock seedlings are grown in the ground in large numbers in rows in a nursery. When they are about a year old, they are grafted by budding. It consists in inserting a single detached bud of the scion branch into the stem of the stock. Small branches containing plump buds of a selected scion tree can be brought wrapped in moist sphagnum moss or sawdust from any far off place, and the stock seedlings can be budded with them *en masse* with little expense, and obviously, can be reared in a ground nursery much more economically than the hand-watered inarch-grafts in a pot nursery. The method of budding the mango found by the author to be the most easy and commercially successful at the Ganeshkhind Fruit Experiment Station, Poona, is called the Forkert Method of Budding.

Forkert Method of Budding. When the seedling root-stocks raised in nursery are about a year old and have attained a thickness of about ½-inch diameter at the base, they are budded by the Forkert Method. The most favourable season for budding is July-August. At this time, the root-stock seedlings are putting forth new growth and are in excellent sappy condition

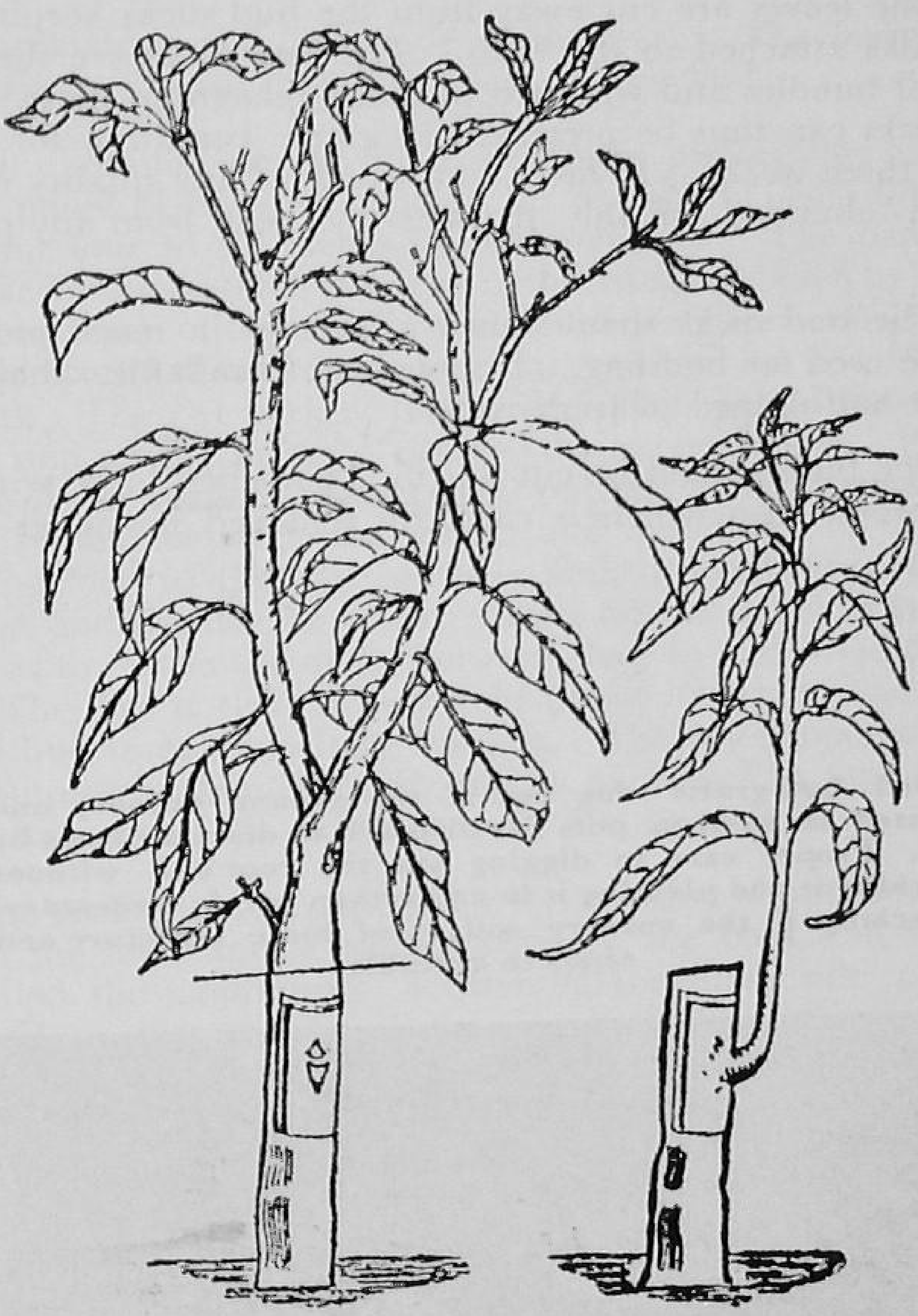


FORKERT METHOD OF BUDDING

(Left) Petioled bud wood ; (centre) bud shield from which wood is removed ; (right) manner of insertion of the bud shield between the exposed panel and the flap of the root-stock



Root-stock budded and bandaged with waxcloth



(Left) Bud showing signs of sprouting. The line above the bud shows the place where the head of the root-stock is to be cut off; (right) budded plant making vigorous growth

and, therefore, their bark separates readily from the wood below during the operation of budding.

The branch of the scion tree called the 'bud stick or 'bud wood' is not a terminal shoot of the past season's growth but the growth just below it which is older by a year. The buds on the bud wood should be swollen and should look prominent in the axils of the leaves. Several such bud sticks about nine inches in length are cut and removed from the scion tree. On removal from the parent

tree, the leaves are cut away from the bud sticks keeping the leaf stalks attached to the buds. The bud sticks are then tied in small bundles and wrapped in moist sphagnum moss. The bud sticks can thus be preserved in green condition for about two to three weeks. In fact, bud wood of any quality mango can be obtained in this manner by post from any part of India.

The bud sticks should always be kept in moist moss till they are used for budding. If moss is not available, they may be kept half-dipped in fresh water.

The buds should be cut $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long with an ample wood chip which is carefully removed by finger nails,

Balled bud-grafts dug out of the ground nursery and planted in earthen pots for dispatch to distant places by rail. Proper care in digging out the root ball without cracking it and planting it in an earthen pot is necessary, especially if the nursery soil is of loose structure and tends to crumble

without scratching the inner side of the bark. The leaf stalk is then trimmed away carefully close to the bud.

The operation on the stock consists in pulling out a rectangular panel of bark at a point in a smooth place on the stem about four to six inches from the ground. The panel is first marked out by a transverse cut in the bark, and then by joining the two ends of this cut by two parallel vertical cuts. The size of the panel should be a little larger than the size of the scion bud. The cut bark of the panel is then pulled down by hand in one strip, so as to expose the wood below. While the bark of the stock is being pulled out in the above manner, the bud is held between the thumb and fore-finger of the left hand. As soon as the flap has been pulled downwards sufficiently, the bud should be gently placed on the panel in such a manner as to rest in the angle between the flap and wood of the stock. The flap is then loosely held up in its original position over the bud so as to entirely cover it. The whole operation is then completely bandaged by means of waxcloth tape so as not to allow water or air to get into the operation.

The healing tissue responsible for bringing about the union between the stock and scion lies between the bark and wood. It is called the cambium. Scratching the inner side of the scion bud or the surface of the wood of the stock with the grafting knife, or the exposure of the operated parts to the outside air for more than three to four minutes would kill the cambium and the operation would be a failure. To ensure success, therefore, it is absolutely necessary that the operation is done swiftly without any loss of time and without damaging the cambium with the edge of the knife. It is better that the stock is first operated and then the scion bud is removed and prepared for insertion.

After three weeks, the bandage is opened. If the operation is successful the bud will appear green, fresh and united with the stock. The flap of the stock is then cut away below the bud. The bud is then once again tied up above and below leaving the centre unwound, so as to expose its growing point.

The bud begins to sprout in about 20 days after it has been exposed or 40 days after budding. The part of the stock above the bud may then be cut and the bandage removed. Plants budded in August or September usually make one or two vigorous flushes of growth during the warm weather in October and then remain dormant throughout the winter. Again, with the advent of spring they grow so vigorously as to put forth as many as three more flushes during the following hot season, and the height of the plants thus raised generally varies from three to four feet during the next monsoon when they are

An unpotted, balled bud-graft: if the soil of the nursery is a retentive clay loam, there is no fear of cracking the earth ball and injuring the roots while digging out the plant. The plant need not even be potted. The earth ball can simply be tied in a piece of gunny cloth (as shown here) and immersed in water for a few minutes before packing the plant for a long railway journey

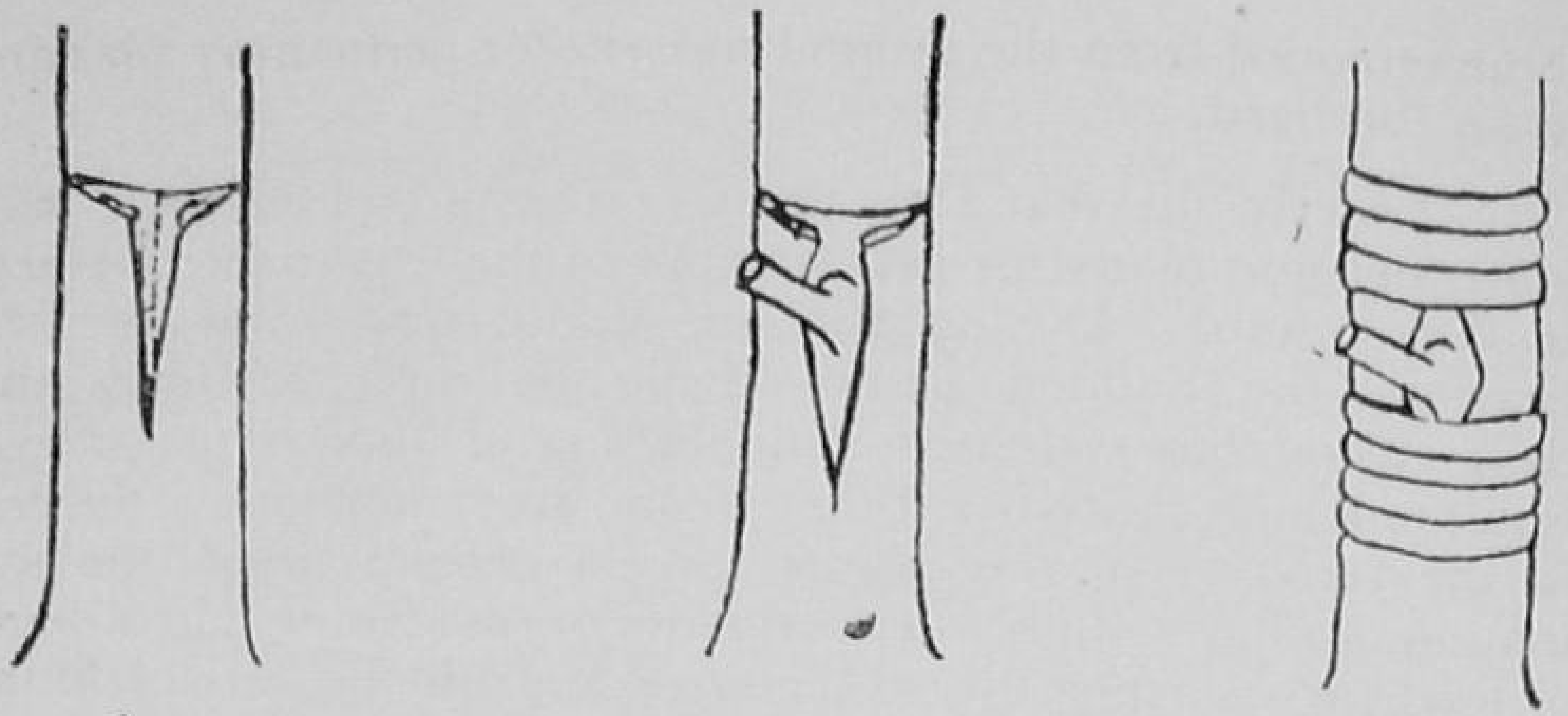
to be removed from the ground nursery for permanent planting in an orchard.

Exactly one year after the operation of budding, the bud-grafts become ready for planting out in their permanent places in the orchard. During July or August when rains are the heaviest, the budded plants should be carefully lifted with their entire root system intact. Lifting of budded plants may result in a high mortality if the roots are damaged. Success in the removal of the plants largely depends upon the formation of plenty of fibrous roots close to the stem within a depth of four inches from the soil surface and on the careful lifting of the ball of earth containing these roots. The formation of a large amount of fibrous roots near the surface can be achieved by applying heavy doses of organic manures like castor or groundnut cake near the stem and timely irrigations during the dry seasons.

It is necessary to water the nursery about three or four days before lifting the plants if it is not raining and the land is dry. The minimum size of the root ball which should be lifted so as to preserve the most vital part of the root system is about 3½ inches all round the stem and seven inches deep. The soil around the plant may be dug to a depth of about eight inches and the tap-root should first be cut at the bottom before the earth ball is lifted. In difficult crumbly soils the lifting is made easier by cutting the tap-root of each plant two months before it is to be removed from the nursery. This operation will also help in encouraging more fibrous roots near the soil surface which are most desired for success in transplanting. The plants with earth balls of the size 3½ inches × 7½ inches can be easily placed in earthen pots of a little larger size and transported by rail to any distance in India as economically as with inarch-grafts. If the soil of the nursery is a clay loam holding the roots well and not crumbling, it may not be necessary at all to transplant the bud-grafts in an earthen pot. The root ball as directly dug out from the ground can be simply wrapped and tied in gunny cloth and immersed in water for a few minutes before the plant is packed in a crate for despatching by rail.

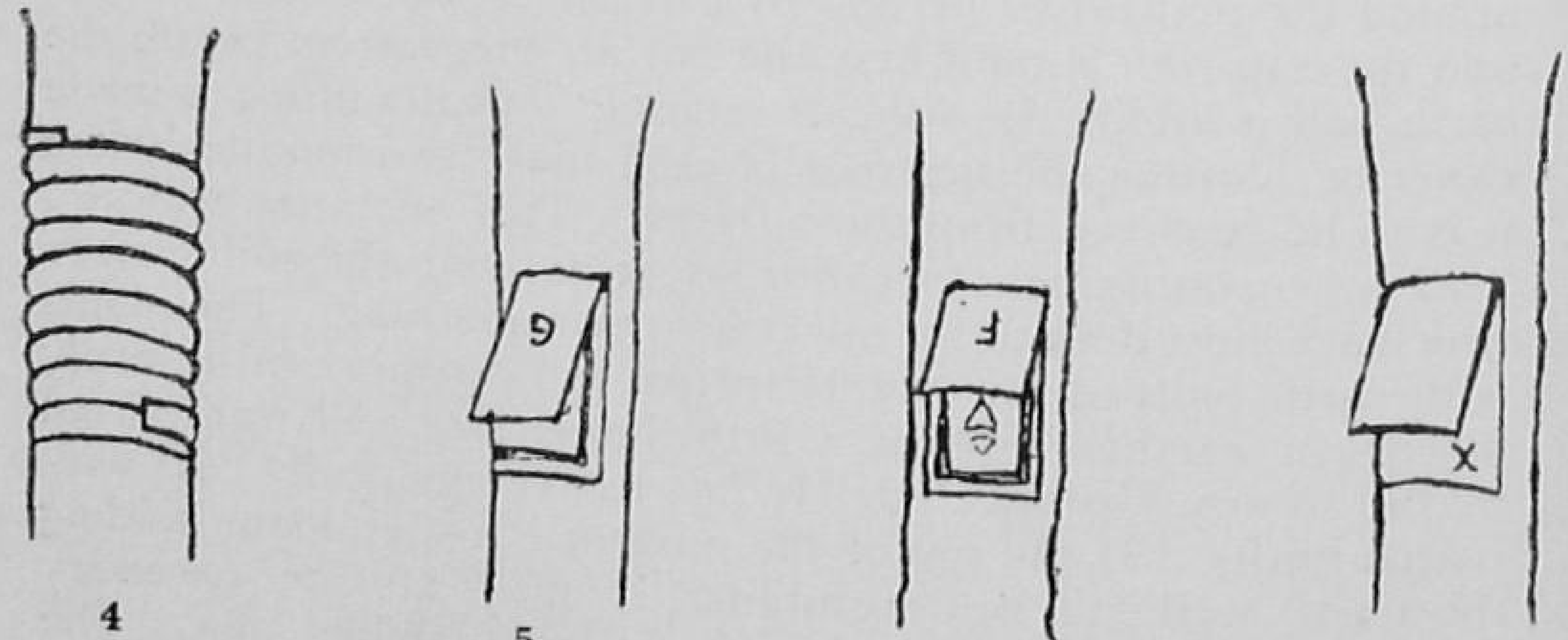
In Sind, the Punjab and South India, even the ordinary 'T' method of shield budding which is usually adopted for budding oranges all over India, is reported to have been successfully employed for budding the mango. In this method, the incision is made in the shape of the letter T and the bud is pushed downwards into the cut.

The Forkert Method of Budding should give a much greater percentage of success than the 'T' method, as in the former the cambium is never injured while operating the stock and remains protected from desiccation due to complete wrap-



1 2 3

The Forkert Method (below) is safer than the 'T' Method (above). 1 shows the cambium injured at dotted line while making the vertical cut in the 'T' Method. The bud inserted at 2 is in contact with the injured cambium. The bandaging of the bud shown at 3 keeps the growing point and the sides open to desiccation. Contrast this with the Forkert Method below. The surface of the wood X at 4 on which the bud is



4 5 6 7

to be applied, is untouched by the knife. 5 and 6 show how the bud fits over the uninjured cambium overlying the wood. In 5, the flap F is cut half way just before the leaf scar of the bud, while in 6 the full flap G covers the bud. Half flap or full, experience shows, makes no difference in the success of the Method. In 7, the waxcloth used for bandaging the operation prevents outside air coming in contact with the wound

ping of the operated parts with the waxed tape. In the 'T' method, however, there is every likelihood of the cambium overlying the wood of the stock being scratched with the

budding knife of an inexperienced operator. Also, the operation being only partially covered by the bandage, the air gets into the operated parts and desiccates the cambium.

It may be interesting to note here that the Forkert Method was perfected in Java (Indonesia) to bud rubber plants which did not respond well to any other method of budding. In fact this is the only method successfully employed for propagating the mango in that country as well as in Ceylon. However, in view of the reported success with the various methods of budding in different parts of India, the actual method of budding is no longer a problem as it used to be a decade or two ago.

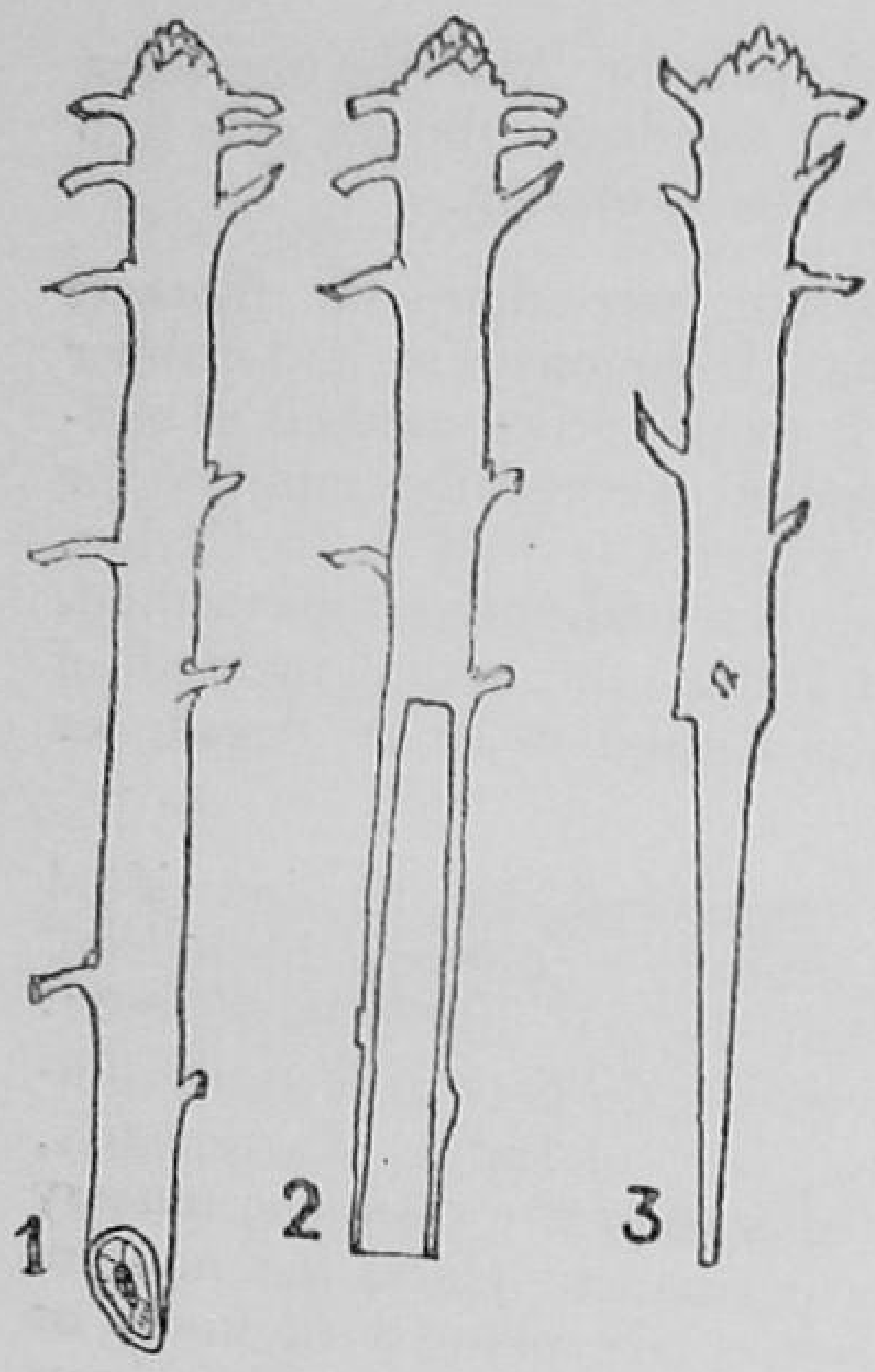
Any method successfully employed by an individual nurseryman to bud the largest number of seedlings in his nursery is the best method for himself, but the soil and cultural treatments to be given to the nursery plants do present certain difficulties to nurserymen in various parts of India. Particularly, the final lifting or the removal of bud-grafts from the nursery for transplanting them in their permanent places has not met with much success where nurseries are planted in sandy or gravelly soils; from such soils it is difficult to dig out the plants without cracking their earth balls and damaging their roots. This and a lack of knowledge about the routine cultural operations are the chief reasons why mango budding has not yet been seriously attempted as a commercial nursery practice by Indian nurserymen.

OLD TREES FOR NEW

In the humid regions of the West Coast of India, viz., the Konkan, Goa and Malabar, even very old country mango trees of huge size and massive trunks growing wild on the slopes of the Western Ghats, are converted into choice varieties by grafting them *in situ* during the south-west monsoon when the atmosphere remains surcharged with moisture.

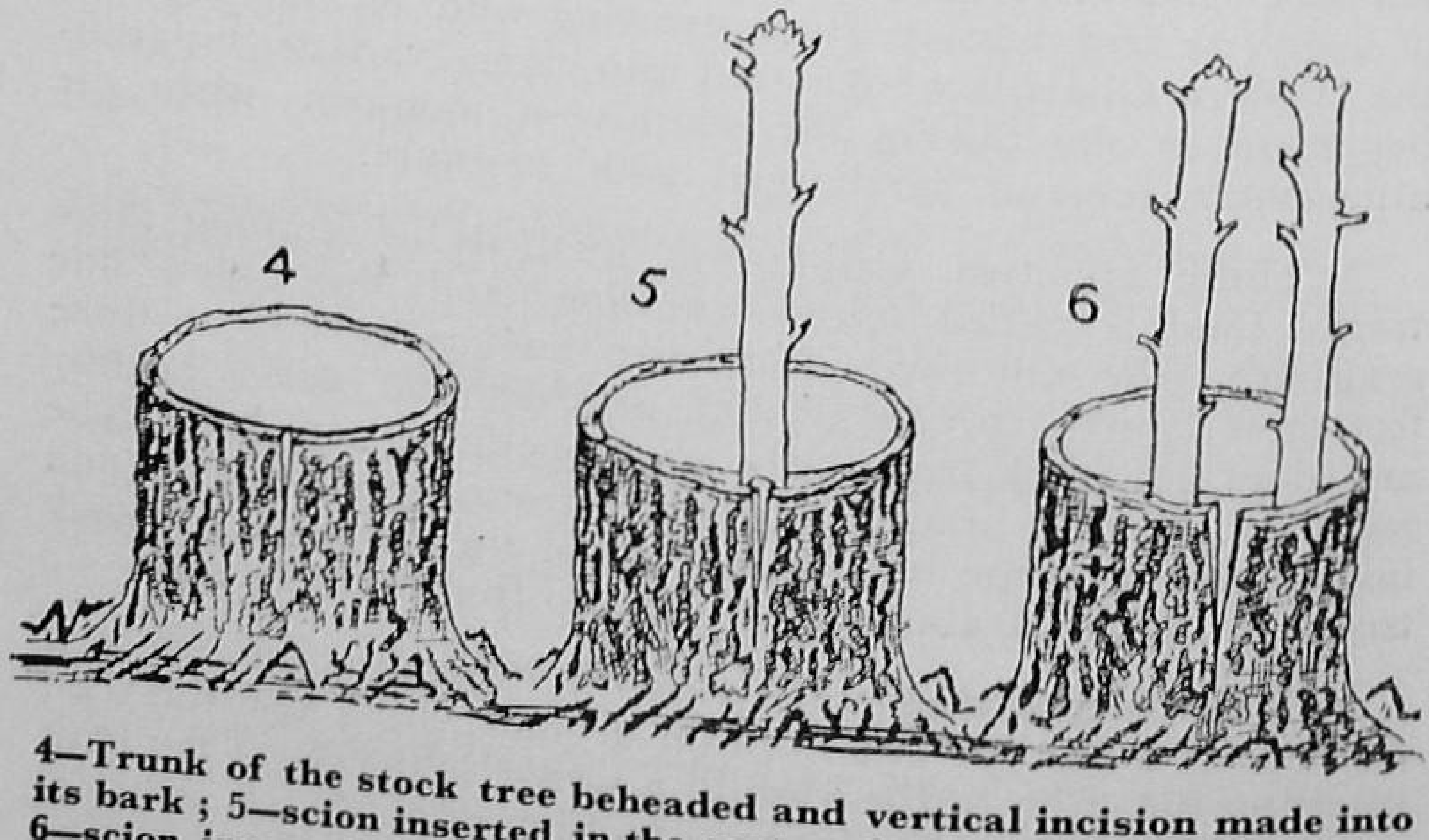
There are two well-known methods of grafting large trees. One is called 'crown grafting' and the other 'side grafting'. Trees of any age and size, having one inch to three feet thick trunks, can be grafted, provided the bark is healthy and does not crack irregularly when operated. In both these methods the scion branch is detached from the parent tree and inserted between the bark and wood of the trunk of the stock tree at a height of about a foot or two from the ground.

Crown grafting. It consists in beheading the tree at a distance of a foot or two from the ground with a saw and then inserting the scion in the form of a wedge in the slit of the bark prepared for it. A longitudinal incision of about 2½ inches is made into the bark beginning from the beheaded top down-



CROWN GRAFTING

1—Scion wood ; 2—scion showing the shape of the wedge ; 3—side view of the wedge cut



4—Trunk of the stock tree beheaded and vertical incision made into its bark ; 5—scion inserted in the centre of the slit behind the flaps ; 6—scion inserted behind a flap on either side of the vertical slit

wards by means of a chisel, taking care that the wood below is not cut or scratched. The bark on either side of the cut is then eased out by means of a smooth ivory or bamboo wedge so that the bark flaps are made wide open to receive the scion. The bark of the stock tree should be thick and, when operated, should separate readily without splitting from the wood below.

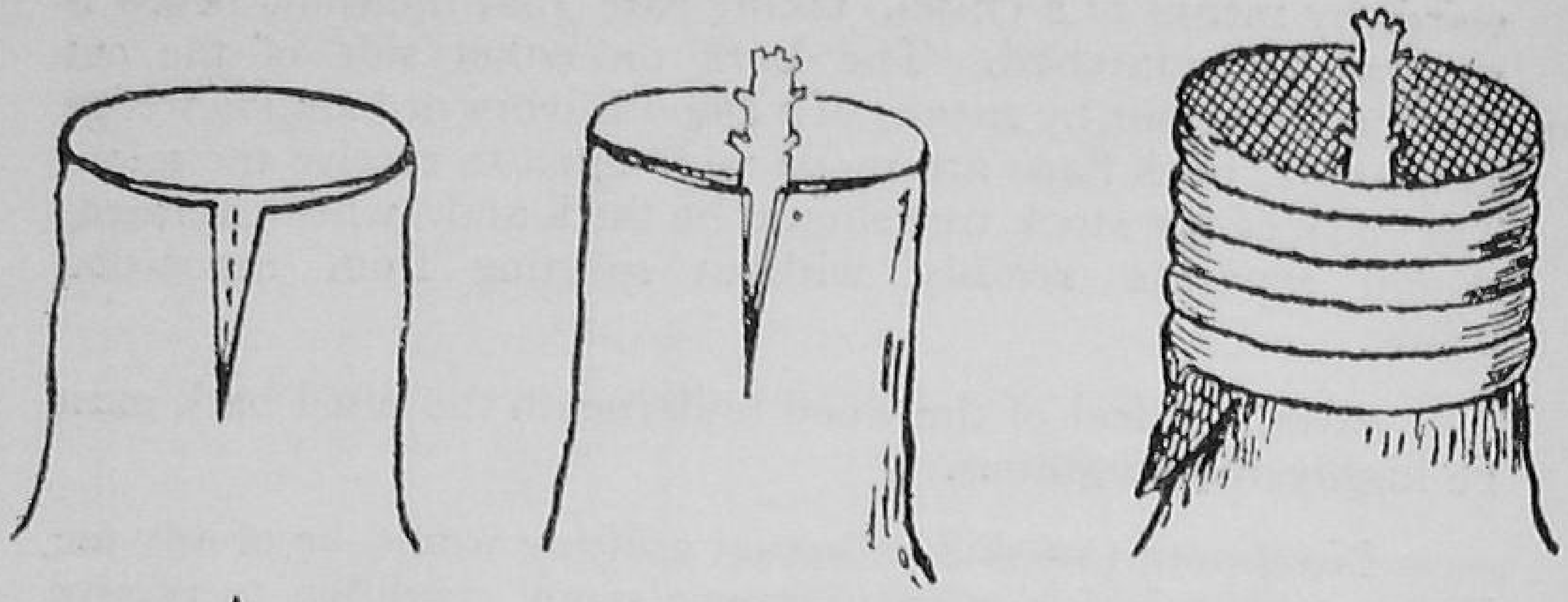
Also, the feel of the wood underneath the lifted bark must be highly mucilaginous.

No amount of skill in actual grafting would be of any use if the stock tree is not in a proper sappy condition to receive the scion. The best time of the year when crown grafting of the mango is successfully done in most parts of India is from August to the middle of October. With the advent of winter in November, the sap activity rapidly slows down and the grafting season can well be said to have closed.

The scion to be used in crown grafting is detached from its parent tree and kept fresh by wrapping it in moist sphagnum moss exactly like the preservation of the bud wood used in budding the mango. It should be a dormant, terminal shoot with a whorl of plump and swollen buds at the top. It should be straight, hard, mature and brownish green in appearance. Its stem should preferably be about half an inch in diameter. It should not be more than seven inches in length. Scions longer than this usually dry up from the top and are apt to fail.

For inserting the scion into the stock it is necesary to mend its lower end in the shape of a wedge which should be about three inches long. The wedge is prepared by cutting the scion slopingly on two opposite sides. The cut which is to face the wood of the stock tree must be made perfectly flat and smooth and should present unbroken, clean edges of bark on either side. The wedge should never be made so thin as to bruise the bark at the time of insertion. If it is bruised, the healing tissue located under it is automatically destroyed and no union takes place between the stock and scion. In preparing the wedge the cut should not be made so deep as to expose the soft pith which lies in the centre of the stem.

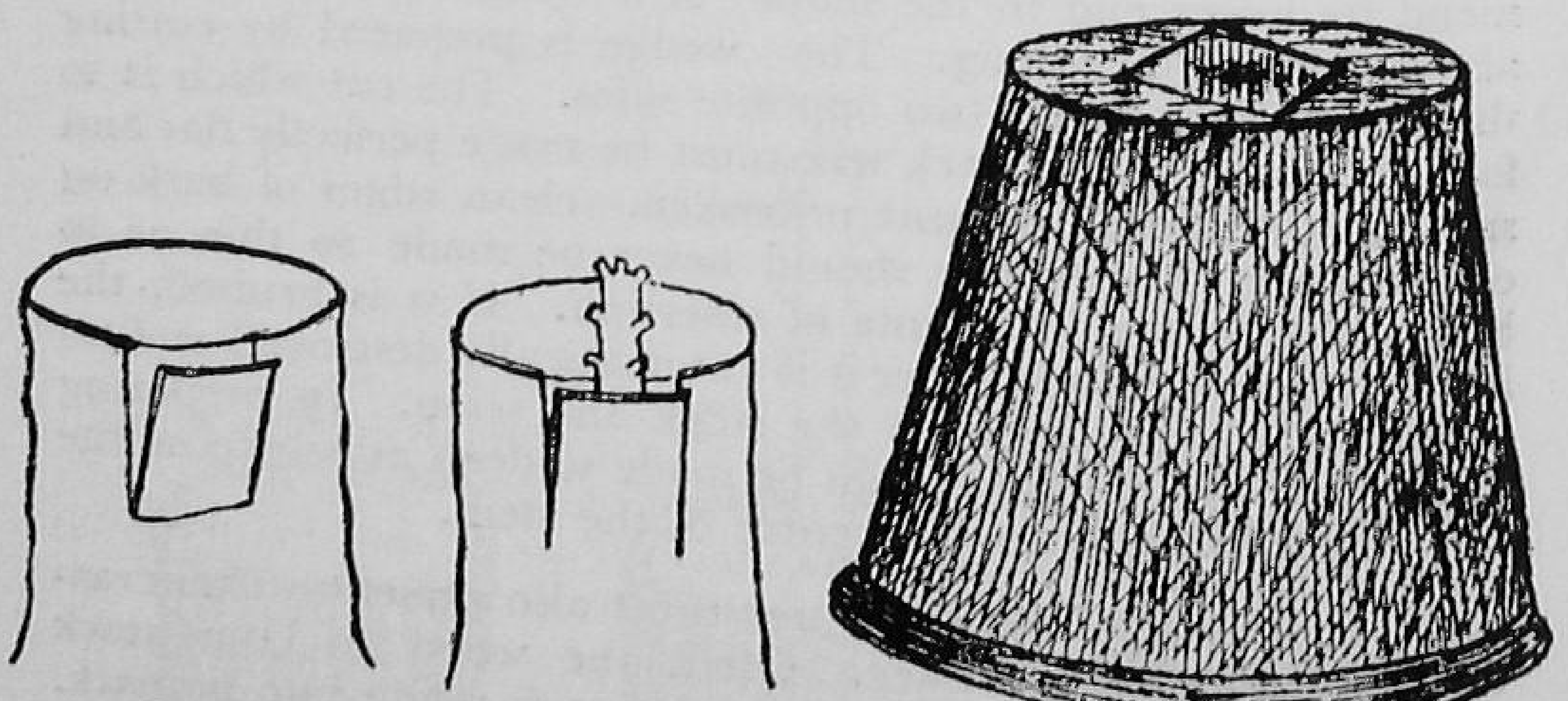
The wood of the stock tree must also present an unscratched mucilaginous surface. Often the wood of the stock trunk gets cut when the vertical incision is made into its bark. If the scion is pushed behind the flaps of this vertical incision, as is generally done by most professional grafters, it is bound to come in contact with the damaged wood of the stock. This would make the union impossible. To avoid this less reliable place for grafting, it is better to ease out the bark of the stock a little sideways of the slit and contact the scion with the entire



A B C

CROWN GRAFTING, OLD AND NEW METHODS

Figures A to C show the method of crown grafting with detached scions. In crown grafting, as opposed to side grafting, the entire trunk and crown of the tree are cut away before grafting is done. B and C show the defective vertical slit operation in which the cambium is injured and the scion fitted over the damaged wood of the stock tree.



D E F

D and E illustrate the Forkert way of pulling the rectangular panel of bark and contacting the scion with the undamaged wood of the stock. After bandaging the wound as in C, the grafted stump is protected by an inverted earthen pot with a glass top to admit light (F).

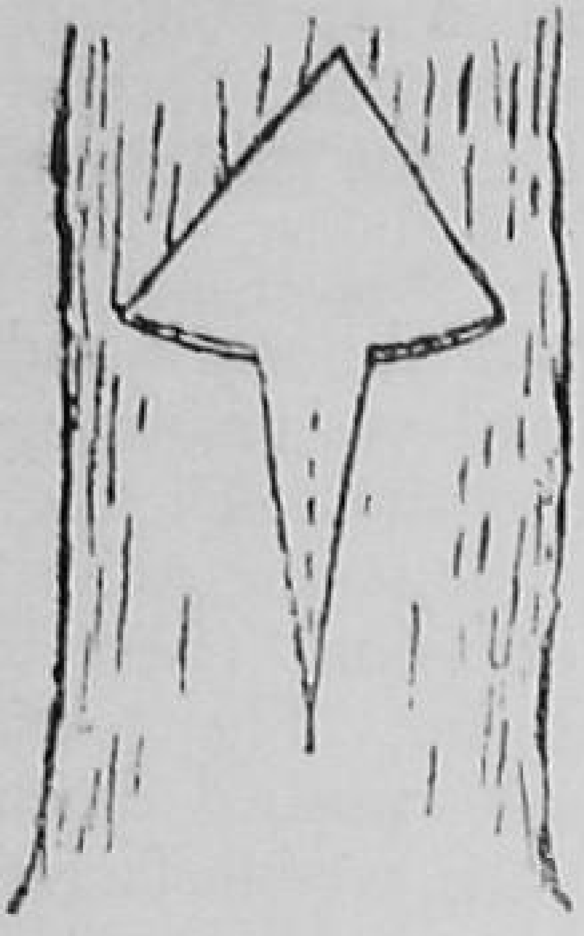
undamaged wood of the stock. Better still, a rectangular panel of bark may be pulled out as is done in the Forkert Method of Budding and the scion applied in the middle of the panel.

So much for the two contacting surfaces of the stock and scion, but a word is necessary for the outward cut or wrong cut of the scion-wedge which faces the bark of the stock tree. This cut does not play any role in bringing about the union. It is made only with a view to facilitating insertion. There is no harm however rough or crude this cut may be. The scion thus cut in the form of a wedge is then gently pushed down sideways of the slit, keeping the right cut of the wedge facing the wood of the stock. More than one scion can be inserted according to the thickness of the trunk.

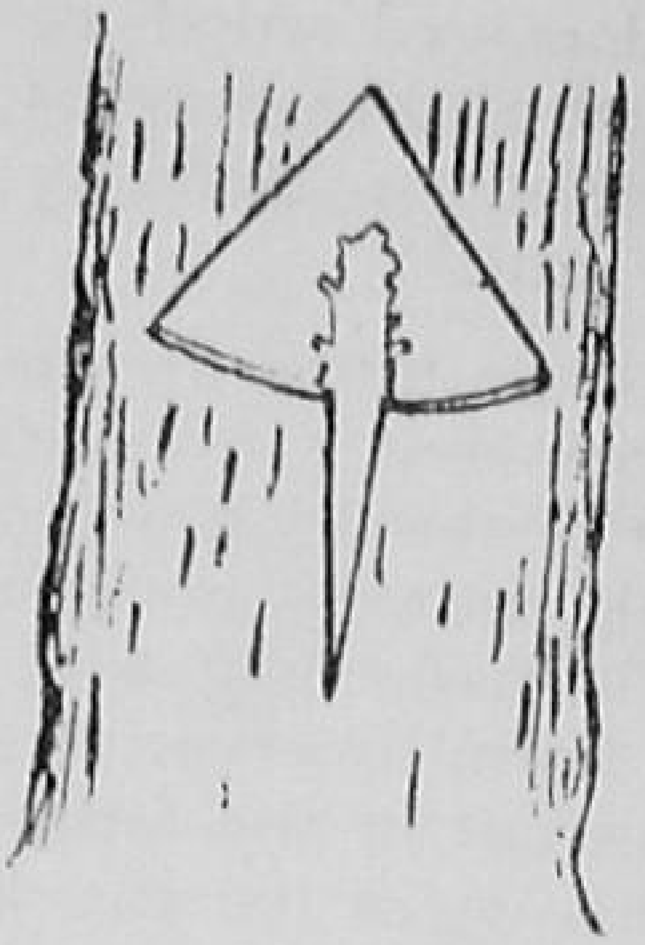
After inserting the scion, it is necessary that all openings in the bark of the stock are immediately closed by means of sealing wax which is made by boiling beeswax, resin and tallow in the proportion of 1 : 2 : 1. The sealing with wax prevents air getting into the operated parts and drying away the inner healing tissue. Also, there is every danger of the healing tissue being killed if exposed for an unreasonably long time during the operation, especially when the sun is bright. The operation is, therefore, best performed in the cooler hours of the morning or evening. A clever and experienced grafter should not take more than five minutes to complete the whole operation. Finally, a piece of waxcloth is wrapped round and tied tightly over the operated parts as well as the beheaded top of the stock.

The portion of the scion now jutting out of the bandaged stump needs protection from the extremes of temperature during the joining period. In the heavy rainfall areas of the Konkan, Malabar and Travancore-Cochin, crown-grafts done during the monsoon sprout satisfactorily without any extra protection, but in the drier regions special arrangements have to be made to create a humid atmosphere around the grafts.

During the joining period which extends over a month, the temperatures around the graft must be equable and a perfectly warm, moist atmosphere must prevail so that the terminal buds of the scion which are already swollen should shoot out into strong shoots with as little delay as possible. To produce the required humid conditions around the graft, a cheap miniature glass-house is constructed over the grafted trunk. This is done by inverting a big earthen pot with a wide hole in its bottom and putting a piece of glass over it to admit light. Again, to insulate the pot, so that the outside air may not affect the graft inside, loose earth is piled all around the pot. The whole structure then looks like a miniature pyramid with



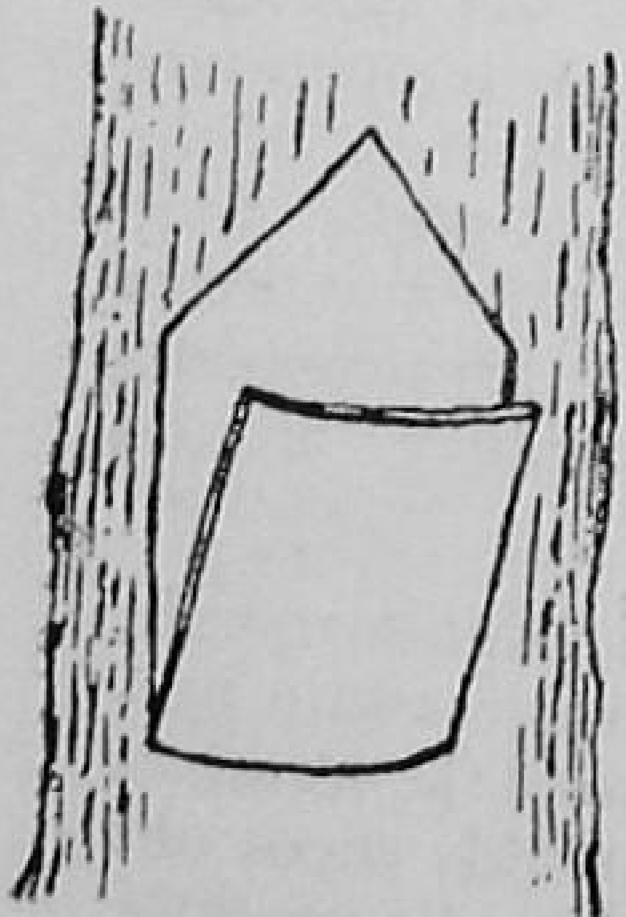
A



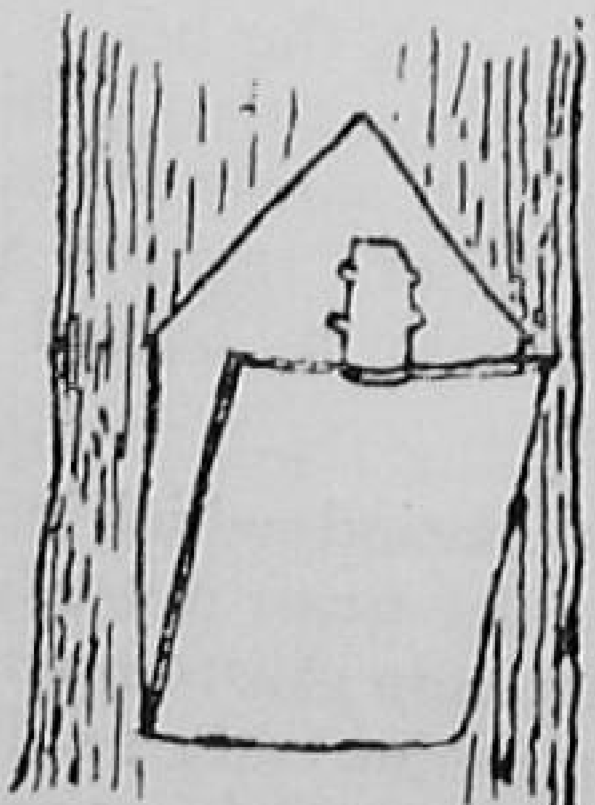
B

SIDE GRAFTING, OLD AND NEW METHODS

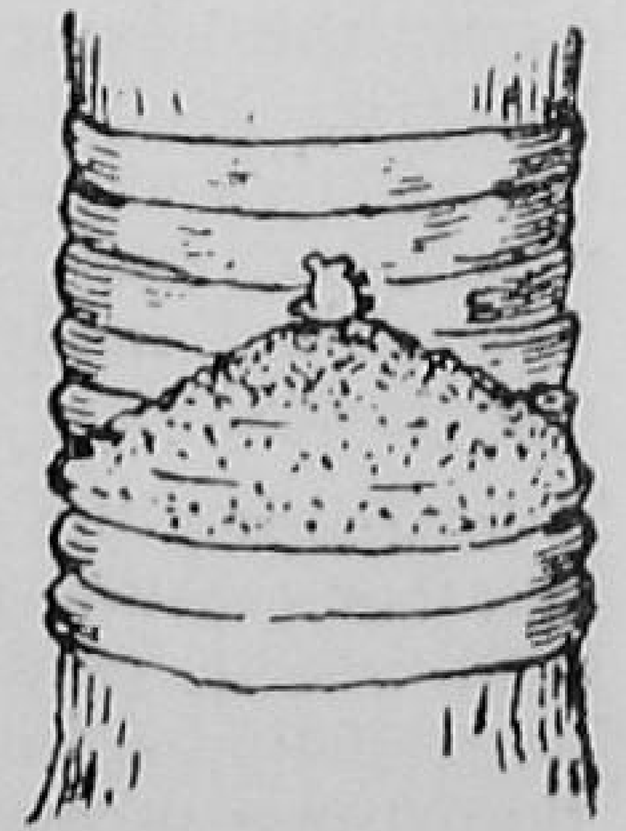
A and B show the side grafting method usually employed in the Konkan to convert old mango trees into choice varieties. The trunk of the tree is bark-grafted with a detached scion at about two feet from the ground surface. When the graft has properly established, the part of the tree above the graft is removed. The bark of the stock is operated by making suitable incisions and a detached piece of scion mended like a wedge inserted exactly in the same manner as a bud shield is pushed behind the flaps of a T-cut in the process of shield budding. This method is as defective as the 'T' method of shield budding, as the cambium gets injured (dotted line) while making the vertical cut through the bark. The percentage of success with this method is extremely low.



C



D



E

C shows the Forkert way of pulling the rectangular panel of bark. A triangular patch of bark is cut and removed over the pulled flap. D shows the filling of the scion snuggly behind the flap on the undamaged cambium surface. E shows bandaging and covering with mud the major part of the scion excepting the terminal buds.

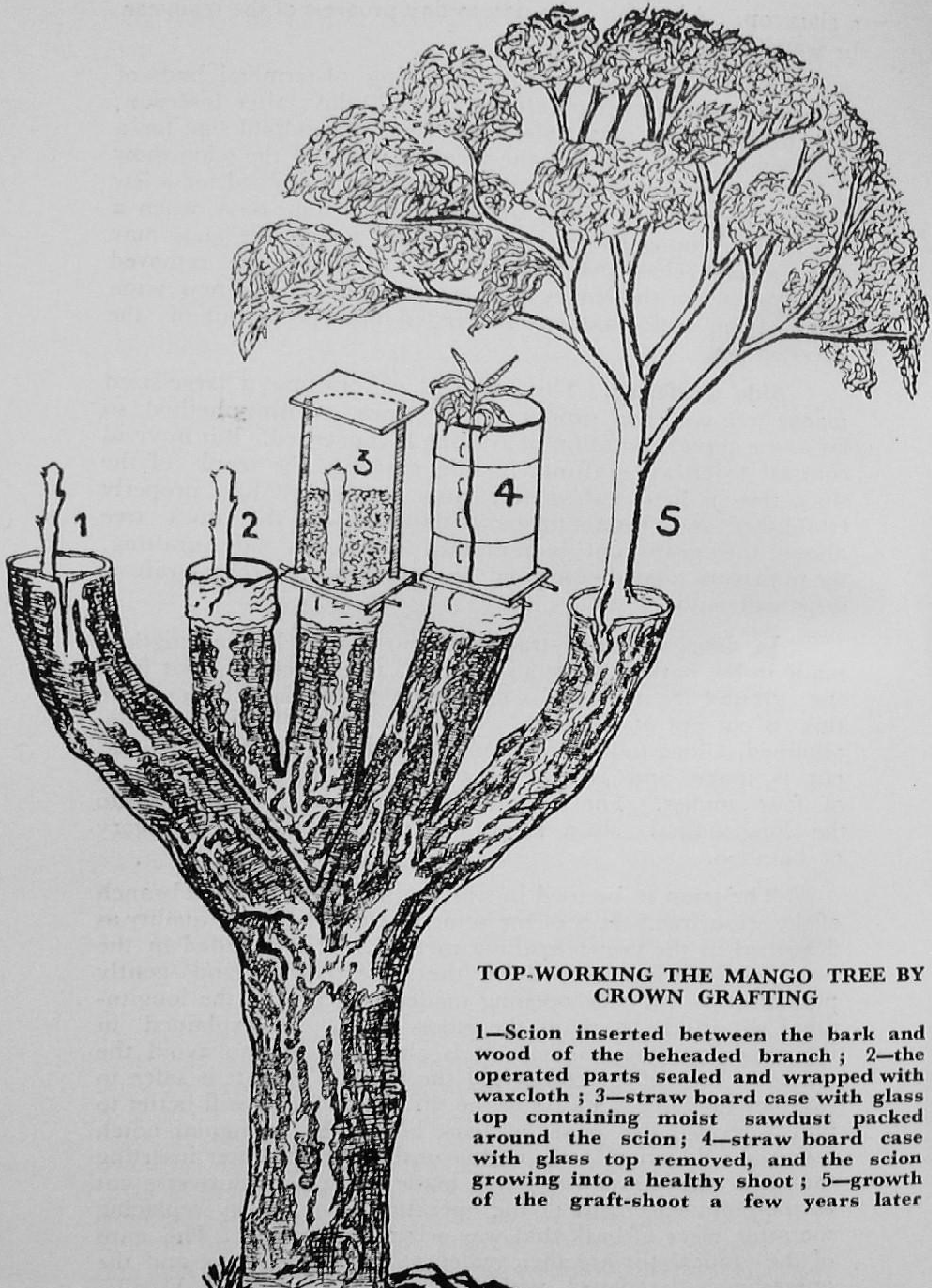
a glass top. After this, the day to day progress of the scion can be watched through the glass.

The healthy and vigorous sprouting of terminal buds of the scion normally occurs almost 15 to 20 days after insertion, and this sprouting may safely be taken as a helpful sign for a prospective union. When the terminal buds of the scion show signs of vigorous sprouting, the glass may be opened for a few minutes every day to admit fresh air. After some days, when a few reddish young leaves have been put forth, the glass may only partially close the hole and it can finally be removed altogether when the leaves have turned green. The new scion shoot of the graft that has succeeded now peeps out of the inverted pot.

Side grafting. This method of grafting a large-sized mango tree is almost similar to the crown grafting method so far as the actual operation of grafting is concerned. But in vivid contrast to crown grafting, in side grafting, the trunk of the stock tree is first grafted and after the scion has properly established and begun to grow, the part of the stock tree above the graft-joint is removed. Also, in side grafting, the miniature glass-house used in covering a crown-graft is dispensed with.

In side grafting, a transverse cut two inches in length is made in the bark of the stock trunk at a distance of a foot from the ground by means of a chisel. A triangular notch above this is cut out of the bark. When a triangular cut is thus obtained, a longitudinal incision in the middle of the horizontal cut is made and is carried downwards up to the length of four inches. The bark is then loosened by inserting into the longitudinal slit a smooth wedge made out of ivory or bamboo.

The scion to be used in side grafting is a detached branch of the scion tree. It is of the same ripeness, size and quality as described in the crown grafting method. It is mended in the shape of a wedge, exactly in the same manner and gently pushed down into the opening made for it behind the longitudinal slit in the bark of the stock trunk. As explained in the crown grafting method, it is also advisable to avoid the centre of the slit for contacting the scion. Thus it is safer to ease out the bark sideways of the slit stock. (It is still better to pull a rectangular panel of bark below the traingular notch and insert the scion in the middle of the panel.) After inserting the scion, the triangular notch made above the transverse cut at the commencement of the operation is closed by replacing the same piece of bark that was originally removed. The gaps of the vertical slit are then sealed with grafting wax and the operation is bandaged with waterproof waxcloth. Finally, as a protection against desiccation, the scion is covered with a



TOP-WORKING THE MANGO TREE BY CROWN GRAFTING

1—Scion inserted between the bark and wood of the beheaded branch ; 2—the operated parts sealed and wrapped with waxcloth ; 3—straw board case with glass top containing moist sawdust packed around the scion ; 4—straw board case with glass top removed, and the scion growing into a healthy shoot ; 5—growth of the graft-shoot a few years later

plaster of cow-dung and mud keeping its top of terminal buds open for growth.

After two or three months when the graft is successful and the scion shows vigorous sprouting, dry earth is heaped over the grafted portion, and the entire crown of the stock tree above the graft-joint is cut off. Watering is given to the tree at suitable intervals if there is no rain, and is continued for about six to eight months till the graft becomes sufficiently established.

Most growers generally prefer to have their large mango trees grafted by the side grafting method and not by crown grafting, as in the former method, the whole tree is not sacrificed if the graft fails to take. However, it must be realised that a side-graft exposed to the outside air during the joining period has less chances to succeed in the dry zones of India with scanty rainfall, whereas the crown-graft, if done by an expert grafter, will succeed in all the difficult climatic conditions as it remains artificially protected by the miniature glass-house which keeps the scion green and fresh during the period of joining with the stock.

Both the side and crown grafting methods can be advantageously used for converting young trees of inferior varieties into choice ones or for rejuvenating very old and exhausted trees which do not bear satisfactory crops in regular orchards. The new scion top growing on the extensive root system of the large tree that has been cut down begins life anew, grows vigorously, bears profusely and lives long.

The chief disadvantage in renewing the top of a mango tree by the side and crown grafting methods is the loss of its massive trunk and framework. The growers are, therefore, generally reluctant to practise these methods on trees above 20 years in age. To remedy this drawback inherent in the above methods, grafting of top branches without cutting the trunk of the stock tree is recommended. The operation of renewing the top of a tree by grafting its main branches is termed 'top-working.'

Top-working. In top-working, the main branches of the tree are pruned back to within two or three feet of the main trunk. On these beheaded branches scions of choice varieties can be grafted by various methods. The usual method of top-working practised is called inarching. The massive branches, a little above the trunk of the stock tree, are cut down to a convenient height and new shoots are encouraged to grow near the cut end ; these, when mature, are grafted by inarching. This process involves the transfer (by inarching) on the new stock shoot, a scion branch which has already been inarched and reared for about a year on the body of a one or two-year old mango seedling grown in a small earthen pot.

This process is tedious, laborious and very expensive. Bud-grafting the new stock shoots would be less expensive and cheaper. But the top thus renewed by grafting the new shoots individually grows slowly and unevenly. The new method of top-working by crown grafting the massive branches enables the tree to develop to its original size in the shortest time possible.

Top-working by crown grafting. For top-working a large tree its main branches are cut back or beheaded within three to four feet from the top of the trunk. Out of these branches, those that are vertically growing are better suited for crown grafting. The entire technique of the operation of grafting is just the same as in crown grafting except that the miniature glass-house or the graft-protector is different from that used for crown grafting the trunk of a tree near the ground level.

We have seen that in the crown grafting done very low on the trunk the irrigated wet ground constantly evaporates enough moisture to produce the required humidity in the pot that encloses the grafts. If, therefore, we want to succeed with crown grafting high up on tree branches we should be able to produce similar humid conditions there too. To maintain this humidity, the author has perfected a special but simple device. It consists in providing a straw board case round the operated part and filling it with moist sawdust up to the top buds of the scion and putting a piece of glass overhead to admit light. The sawdust has to be kept constantly moist by watering it on alternate days till the graft is established. Care has also to be taken to irrigate the stock tree every week, so as to keep it in a vigorous sappy condition. Everything else done in connection with this grafting is exactly the same as described in the crown grafting of trunks near the ground level.

PLANTING THE MANGO

PRIOR to the planting of the trees, the field should be deeply ploughed, harrowed and levelled. It is best to purchase mango grafts from nurserymen a few days before they are required for planting. The best time for planting all over India is during the monsoon when the air remains surcharged with moisture. In the heavy rainfall tracts, mangoes are best planted near the end of the rainy season so that the young plants may not be damaged by heavy floods or stormy winds. In the light rainfall tracts the mangoes can be planted with advantage in the beginning of the monsoon.

In North and western India, July-August is the best time for planting ; July to December is the most suitable period in many parts of South India which get rains from the

south-west as well as the north-east monsoons. During the break in the rains if the weather tends to become dry, the best time for planting is the evening. If the planting is done in the morning and if the day turns out to be unusually hot, the plant may wither due to excessive loss of water from its leaves.

The distance of planting mango grafts varies from place to place according to the natural growth the mango makes in certain environments. Where the growth of the mango is very luxuriant and where the tree attains a huge size the distance is about 40 feet from plant to plant on the square system, but in the dry zones where the growth is sparse, the distance may range from 30 to 35 feet. In deep, loamy soils pits two feet wide and two feet deep may be dug at the required distance. In the shallow soils of hilly tracts three feet wide and three feet deep pits are deemed necessary for planting mango grafts. It is not all necessary to dig pits deeper than this.

On the slopes of the laterite hills of Ratnagiri on the West Coast, mango grafts are planted 40 to 60 feet apart at random wherever deep soil pockets are available. It does not matter if large boulders of lateritic rock exist by the side of the pit. The roots of mango are strong enough to get around the boulders and make way through the softer layers of the soil. In the valleys, the distance of planting is 60 feet as the trees there grow much bigger in size than those on the slopes and top of a hill.

Pits should be refilled with original soil mixed with manures. A mixture of 100 pounds of well-rotted farmyard manure, five pounds of bone-meal and 10 pounds of wood ash is recommended for mixing in the soil of a pit three feet deep and three feet wide. Smaller quantities of each of these manures may be used for filling smaller pits. In the dry zones of North India where there is fear of white ants infesting the soil during the summer, it is dangerous to mix farmyard manure in the soil of the pit as white ants which generally thrive on farmyard manure, would destroy the young tree almost immediately after planting. Under such conditions it is better to drop the farmyard manure from the manure mixture and replace it with five pounds of *neem* or *mahua* cake.

If the subsoil in the pit is of a poorer quality than the topsoil, as it often happens in the hilly regions, it is necessary to discard it and fill the pit with only the topsoil mixed with the necessary manures. The pits should be filled before the rains break and left to settle down under the influence of the early showers before the planting is done.

PLANTING OF POTTED MANGO GRAFTS

Since mango grafts are usually sold in earthen pots, it is necessary at the time of planting to remove the root ball

carefully by breaking the pot. The undisturbed mango plant with its unbroken root ball as taken out in its entirety from the pot is then placed in the centre of the pit by excavating as much soil as is necessary to accommodate the root ball. The moist soil of the pit is then very firmly pressed all around the root ball and the planting completed. A small basin is then made and the plant thoroughly watered. The planting of the mango graft should not be done so low as to bury its graft-joint in the soil or so high as to expose its upper root. It is best to plant the tree at the same depth in which it was in the pot or nursery bed.

The system of manuring the soil of the pit before planting the grafts on the laterite hill slopes at Ratnagiri on the West Coast, in view of the humid and windy environments of the place, differs remarkably from the system adopted elsewhere in the drier plains of India. The large pits made for planting are filled with the original soil and green leaves of forest trees in alternate layers as no farmyard manure is available in sufficient quantities in this tract. Instead of green leaves, in some places choppings of *nivadung* (*Opuntia decumana*) and *thor* (*Euphorbia neriifolia*) are placed in alternate layers with the soil. This system of incorporating unrotted green stuff with the soil of the pit works well in the humid regions where white ants do not exist and the strong monsoon rains cause quick rotting of the material.

After planting, the stem and the branches of the graft are supported by means of bamboo sticks so that they do not break due to strong monsoon winds.

SEEDLINGS IN SITU

If the potted grafts purchased from a nurseryman are not well made, or if they have been kept too long in the nursery and, therefore, have their roots twisted and badly cramped, they do not make a good start after planting and often die out in spite of good cultivation. In such circumtances when a grower finds it difficult to establish an orchard with potted grafts, he is advised to grow stock seedlings at the required distance in the previously prepared pits and bud or side-graft them *in situ* after a year or two.

Sow about half a dozen, good, freshly extracted mango stones in each pit. Let them grow for about six months. Then retain only one strong seedling in each pit and uproot the rest. The seedlings growing in the ground rapidly produce a powerful tap-root which in the field goes deep into the ground and branches to produce a large and efficient root system. The seedlings are watered at suitable intervals, say, twice or thrice in a month, during the dry weather. These plants grow vigorously as the root system is not disturbed. One year after sowing the seeds, in the next monsoon, the

seedlings can be budded, or two years after sowing the seeds when the seedlings have attained two inches thickness, they can be side-grafted *in situ*.

TRAINING AND PRUNING OF YOUNG TREES

The mango naturally assumes a graceful, dome-shaped form perfectly shading the trunk. Often, this dome-like shape is wanting in grafted trees due to the selection of bad inarch-grafts made from crooked scion branches. It is necessary, therefore, that the grafts selected for planting should be as straight-growing as possible.

After planting, the young graft should be allowed to grow unhampered for at least four years before any pruning of the scion-top is seriously taken up to correct its shape. An inarch-graft begins to branch sideways often very near the ground level. In a grafted mango any attempt to raise the crown much above the ground level and have a clean tall trunk by means of pruning away side-growths of the main trunk in the early years of the tree, is attended with great danger of making the tree top heavy and susceptible to wind injury and the trunk liable to severe sunburn. Also, any removal of side-growths during this period will seriously tell upon the natural thickening of the main trunk and subsequent development of the crown.

At the end of the fourth year, the removal of crossed branches which crowd the centre of the tree and weak growths underneath the main branches which remain under perpetual shade should be carried out, as they would ever remain unfruitful, not being fully exposed to sunshine. Ordinarily, however, a young mango tree will have very few such shaded branches which require to be pruned away as undesirable, and often none at all. It must be borne in mind that every healthy branch of mango in whatever position on the tree, if its leaves are fully exposed to the sun, is an asset for fruiting in future ; therefore, on no account should it be pruned unless it deteriorates due to want of sufficient sunlight or is in any way diseased. This rule must apply to mango trees of all categories, young or old, grafted or grown from seed.

CARE OF THE YOUNG ORCHARD

Any growths appearing on the stock part of the young plant below the graft-joint should be removed as soon as they appear. If allowed to grow they would suppress the growth of the scion and eventually kill it. Ordinarily, the stock does not give out any growth unless the scion is weak at the time of planting.

Removal of premature blossoms. The young mango

graft often begins to flower in its first year of life. All flowers that may appear during the first three years should be removed as soon as they appear. They seldom set fruit and their presence would mean suppression of corresponding vegetative growth which is so essential in building up the constitution of the young tree.

Fencing. The area in which the grafts are planted must be thoroughly fenced in or each individual graft should be fenced round temporarily by growing a live hedge of *Euphorbia tirucalli* (milk hedge) or some other similar Euphorbias which can easily be grown from large cuttings, in order to prevent cattle and goats devouring the tender shoots. The Euphorbias serve as the best fencing as they are not eaten by cattle or goats and at the same time, being sparsely rooted, do not compete with the young mango plants for moisture in the soil. The fencing will also protect the young plants against sunburn during summer in the dry regions of India.

Irrigation. Small, round irrigation basins and water channels should be prepared, and in the first year the plants watered at intervals of two to three days. On slopes of hills such as at Ratnagiri and elsewhere in the Western Ghats, plants are watered by hand. No watering is required during the monsoon except in the intervening spells of dry weather. From the second year, during winter water may be given to young trees at intervals of a week and during the hot weather at intervals of four to six days or even at shorter intervals depending upon the nature of the soil and severity of the weather. After five years, the mango trees will grow and fruit satisfactorily without irrigation in most parts of the peninsular India, but in North India they may have to be irrigated throughout their life if satisfactory crops are desired.

Manuring. The best time for manuring the young plants is the beginning of the monsoon under tropical conditions and two months before flowering in subtropical climate. For a year-old plant, a mixture of 20 pounds of farmyard manure, five pounds of bone-meal and 10 pounds of wood ash is recommended. As the plant grows older this dose may be increased each year by 10 pounds of farmyard manure, one pound of bone-meal and two pounds of wood ash till the total per tree amounts to 100 pounds of farmyard manure, 15 pounds of bone-meal and 30 pounds of wood ash in the ninth year.

The manure should be well-dug into the ground in a trench two feet broad, six inches deep and one foot away from the trunk in a year-old tree. The trench should be widened about six inches and its inner edge taken six inches further from the tree every year.

White ants. White ants abound all over in the Indo-Gangetic alluvium of North India and they destroy the young grafts especially during the dry weather in summer. The best way to control white ants is to pour about ½ gallon of 0.2 per cent DDT water suspension around each graft in the beginning of October soon after the monsoon is over. Castor cake, *neem* cake or *mahua* cake mixed in irrigation water would work as a good nitrogenous manure and also as a deterrent to white ants. Soils abounding in white ants should never be allowed to go too dry as it is in the absence of adequate soil moisture that the white ants thrive and multiply. Such soils should, therefore, receive ample irrigation during the dry season.

Frost. Frost rarely occurs in the peninsular India but it is often experienced in many parts of North India in December to early February. It is usual in North India to cover young plants of mangoes during the winter on top and three sides with thatch, keeping the south-east side open for light and sunshine. Such a cover is quite effective in saving the young plants from being killed by frost.

Inter-crops. In a young mango orchard there remains a great amount of unoccupied space for a number of years till the trees grow to a size big enough to cover the ground. During the first five years of the life of the plantation and later if the ground does not become too shady, short-season crops may be taken between the trees. Where water is scarce, rainy season vegetables like brinjals, chillies, tomatoes, peas and beans may be raised during the rains. Where irrigation facilities exist cabbage, knol khol, turnip, onion and sweet potato may be grown in the cold weather. Tall-growing crops should never be grown as inter-crops as their shade interferes with the vigorous growing of the young trees. The cultivation of inter-crops should not be carried so close to the trees that they get injured by the working of animals.

TREATMENT OF BEARING FRUIT TREES

The orchard should be ploughed and harrowed at least twice annually, once in the beginning of the monsoon and again at the close of the rainy season, so as to remove the weeds and mulch the soil.

Manuring. In most parts of India, bearing mango trees of advanced age are not at all manured, but the evidence gathered from the growers who do manure their trees indicates that the practice of manuring the trees annually is highly beneficial and considerably increases the bearing capacity of the trees. A general surface manuring of the orchard with farmyard manure at the rate of 10 cartloads to the acre should be done every year at the commencement of the monsoon. Besides, every individual

tree should be manured especially in the year in which it has yielded a large crop. For an individual tree of 10 to 20 years, a mixture of 100 pounds of farmyard manure, 15 pounds of bone-meal and 30 pounds of ash is recommended. Trees bigger in size and older in age need proportionately larger quantities.

While applying the general dose of farmyard manure, it may be spread evenly on the ploughed surface and incorporated by harrowing. The manure mixture given to individual trees should be applied in a circular trench two to three feet wide and one foot deep under the inner fringes of the tree's canopy.

Weakling trees which are found turning yellow and declining in yield and not putting forth new growths should be given ammonium sulphate at the rate of five pounds (for 6 to 10-year old trees) and 10 pounds (for 10 to 20-year old trees). Ammonium sulphate is a quick-acting nitrogenous manure which invigorates the tree within three months of application and makes it put forth healthy growth. The fertilizer is easily soluble in water and, therefore, it is best applied on the surface of the soil and dug in round the tree in a ring three to four feet wide under the drip of the tree crown.

After applying ammonium sulphate, a light irrigation should be given. Ammonium sulphate should not be given when it is heavily raining as it is likely to be leached out into lower layers of the soil beyond the reach of the roots of the tree. In fact, in heavy rainfall tracts it is more advisable to give ammonium sulphate at the end of the monsoon when the rains are light.

Irrigation. As a rule, a grafted mango tree requires irrigation only for the first four years of its orchard life. By this time it has developed a deep and extensive root system, and can grow and fruit in later life without any irrigation, except in very hot, rainless regions or in extremely shallow soils.

In areas with good rainfall from June to September and deep soils, it is not at all advisable to irrigate the tree during winter before the flowers appear and fruits are set, as the soils are able to retain just sufficient moisture required by the tree for flowering freely. Excess of moisture in the soil after October may retard flowering. On the other hand, in areas with scanty rainfall and sandy or shallow soils one good irrigation in November or December may induce good flowering.

In North India, bearing trees are as a rule not watered before flowering but they are watered four or five times between the setting of the fruit in February and the commencement of the south-west monsoon in June or July.

FLOWERING AND CARE OF BLOSSOMS

The grafted mango begins to bear fruit from the fourth or fifth year of planting. The time of flowering in different regions is greatly influenced by local weather conditions. In Rayalaseema in Andhra and the South Konkan on the West Coast, the mangoes may begin to bloom as early as November in some years though usually they start flowering in December. In most parts of the peninsular India, December-January is the usual time for mangoes to flower. In many parts of North India, the mangoes flower late in January or in the beginning of February or even as late as March in some submontane districts. Flowering continues in two or three distinct flushes for a period of six to eight weeks on different branches of trees, and it takes about five months for the fruits to mature and ripen after flowering.

At flowering time, small insects called mango hoppers appear on the flower clusters. They crowd round the flowers puncturing the tissues and sucking the sap. In consequence, the flowers as well as the newly-set young fruits drop. Also, at the same time, a disease called powdery mildew attacks the flowers. Both mango hoppers and powdery mildew can effectively be controlled by dusting the trees with five per cent DDT mixed with finely ground sulphur in equal proportions. (See pages 59-60 for details of dusting).

Abnormal inflorescence. This is a disease of the inflorescence, the cause and remedy of which are not known. The flowers are crowded on short, thick stems. They have enlarged discs, are long in opening and seldom set fruit. A whole tree may be affected or the trouble may be limited to one branch only. A branch which bears abnormal inflorescence for one year may bear normal one or both the types the next year. No insect or disease organism has been discovered associated with this malformation. Some research workers suggest that it may be caused by a virus. Though it casually occurs on mangoes all over India, curiously it is increasing rapidly in the hot plains of North India, particularly in the Punjab and Uttar Pradesh. The only preventive measure that can be recommended is to remove and burn the abnormal inflorescence as soon as it appears.

Loranthus parasite. This a well-known plant parasite which is generally found to grow wild on the branches of mango trees and absorb their sap. It has thick, succulent, light green leaves, pale flowers and bright red berries. The berries are attractive to the birds. The seeds of *Loranthus* which are sticky adhere to the bird's beak and get deposited on the mango branches while the bird scratches its beak on them. The seeds germinate

on the branch and the parasite plant sends its roots into the branch and absorbs its sap. If not removed in time, it kills the branch on which it grows. While removing *Loranthus* care must be taken to cut it out completely from its base deep in the mango branch.

PROBLEMS OF BLOSSOMING AND FRUIT SETTING

The mango produces blossoms and bears fruits mostly from the terminal buds of its shoots and very rarely from the axillary buds. The volume and amount of blossoms put forth by the mango are partly determined by the dryness of the weather in the three months preceding the flowering season. As already explained elsewhere, dry weather stimulates flowering and cloudy weather or winter rains tend to retard it ; but the mango, in spite of a favourable dry weather after October, may refuse to flower and may produce vegetative or leafy shoots only.

In fact, the chief internal factor that governs and controls the entire phenomenon of flowering in the mango is the maturity and age of its seasonal vegetative growths (leafy shoots) which are produced in distinct flushes at certain times of the year. In western India, the mango puts forth new leafy growths thrice in a year. The first flush is produced in the early spring (February-March), the second during March-April or later in the beginning of the monsoon, and the third in the beginning of the winter (October-November), and there may occur some occasional growths in between these main flushes. In Bihar, the first flush is produced in the early spring, the second from April to May and the third in July-August. In Uttar Pradesh (in Saharanpur) only two flushes are generally produced, in March-April and July-August. In the Punjab as many as five flushes are given out between April and August out of which April and May flushes are the heaviest. In South India (at Kodur) mangoes put forth two main flushes, one from February to June and the other in October-November.

Of the various flushes of the above-mentioned seasonal growths, it is mostly the 8 to 10-month old mature shoots that produce flowers. These shoots are produced in the spring and early summer and cease growing at least four months prior to the blossoming season flowers. Other shoots produced in subsequent flushes during the late monsoon and after October rarely blossom towards the end of the winter or in the beginning of the spring which is the flowering time of the mango throughout India. The internal nutritional conditions of the tree favour differentiation of flower buds if vegetative shoots produced in the spring and summer cease to grow early and accumulate sufficient food reserves in their tissues before October. The spring and summer shoots get sufficient time to grow, rest and

mature for the purpose but the later formed growths do not get time to do so.

Though the 8 to 10-month old spring and summer growths as a rule produce blossoms, at times we come across exceptional cases of flowering such as (1) growth made in November, flowering in the succeeding January (two months later), (2) leafless wood several years old and several inches in diameter producing an inflorescence, (3) axillary buds on the same branch developing simultaneously, some into inflorescence and others into leafy shoots, and (4) wood which bore a terminal inflorescence in the previous season bearing axillary inflorescences in the following season with no intervening vegetative growth. Such exceptional cases of flowering very rarely occur due to unexpected concentrations of food reserves in certain parts of the tree and, as such, they do not alter the natural habit of blossoming.

When mango trees are below 10 years in age, they blossom as well as produce a good number of vegetative growths which mature and flower in the next year. Thus a young mango tree is able to bear a regular crop of fruits every year, but the trees above 10 years in age do not generally bear normal crops every year. This is due to the inability of the older trees to produce sufficient amount of leafy shoots in addition to blossoms. In fact, the older trees naturally settle down to a more or less rhythmic habit of producing (1) profuse blossoms and sparse vegetative growth in the spring and summer of one year and (2) profuse vegetative growths and sparse blossoms in the spring and summer of the next year. This habit causes what is called alternate bearing or biennial bearing in mango which means that the mango bears 'fat' and 'lean' crops in alternate years. When the mango bears a heavy crop, the bearing season is called the 'on' year. When it bears a poor or lean crop the season is called the 'off' year.

This habit of bearing heavy and poor crops in alternate years is believed to be inherent in the mango and some other species of fruit trees. The terminals that bear fruits this year will put forth only leafy shoots next year and the terminals that produce leafy shoots this year will produce fruits next year. For instance, if due to some favourable nutritional conditions 90 per cent of the terminals produce a heavy crop of fruits, the remaining 10 per cent will produce only leafy shoots this year, but quite the reverse will be the case in the following year. In other words, the first set of 90 per cent terminals will produce only leafy shoots and the second set of 10 per cent will bear a very lean crop of fruits.

The following statement explains hypothetically, the various phases of seasonal growths that cause alternate bearing in mango in a period of three years. Growers may con-

veniently insert in this statement their own dates of floral and vegetative flushes and try to understand the subject on the analogy of the phases given below :

Profuse flowering in January 1954		'on' year
Sparse vegetative growth in spring 1954		
Sparse vegetative growth in summer 1954		
Heavy crop	May-June 1954	
Profuse vegetative growth in October 1954		
Sparse flowering in January 1955		'off' year
Profuse vegetative growth in spring 1955		
Profuse vegetative growth in summer 1955		
Poor crop	May-June 1955	
Sparse or no vegetative growth in October 1955		
Profuse flowering in January 1956		'on' year
Sparse or no vegetative growth in the spring of 1956		
Sparse or no vegetative growth in summer in 1956		
Heavy crop	May-June 1956	

For producing blossoms, a mature shoot should have its carbohydrate content in much greater proportion to nitrogen but if nitrogen is more than carbohydrates, the shoot will produce more and more leafy growth. Fluctuations in the carbohydrate-nitrogen ratio in a tree are caused, from time to time, mainly by changes in the weather and often by the type of cultivation and manures given. To be able to manufacture sufficient carbohydrates for growth and to accumulate them for blossoming, the vegetative growths produced in the spring and summer seasons should grow vigorously till about August when they should stop growing and take rest for at least three to four months prior to their blossoming time. It is during this resting condition that the proportion of carbohydrates in the branches rises and they are able to differentiate blossom buds.

Briefly speaking, the poor flowering in the 'off' year is the result of poor vegetative growth in the 'on' year and the profuse flowering in the 'on' year is the result of profuse vegetative growth in the 'off' year. Thus, the tree develops an 'on' and 'off' yearly rhythm which goes on regularly until some adverse weather conditions or serious attacks of a disease or pest upset it by causing a serious change in the nutritional balance of the tree. For instance, if the health of the tree remains below normal in the 'off' year due to neglect in cultivation and defi-

ciency of moisture in the soil due to inadequate rains, it is unable to produce sufficient vegetative growth in the spring and summer due to inadequate supplies of nitrogen drawn from the soil and consequently an 'off' year follows an 'off' year.

Similarly, in the 'on' year if the blossoms are destroyed by pests and diseases or by hot winds in early spring or untimely rains during flowering, the crop altogether fails and thus the 'on' year is automatically transformed into an 'off' year. In such a case the stored food reserves of the blossom-bearing terminals which would have been normally used up in bearing the heavy crop (had the flowers of the season not been destroyed), would now be advantageoulsy utilized by the tree in producing a profuse flush of vegetative growths in the early spring which would blossom profusely in the following year and yield a heavy crop. This is how the external conditions often bring about a change in the rhythmic cycle of heavy and poor cropping in alternate years.

In fact, in the rain-fed and neglected plantations of old trees to which usually no cultivation is given in most parts of India, an exceptionally heavy crop is obtained only once in five years, the intervening crops being fair and poor alternately, and it is not an uncommon experience that in some 'off' years the trees fail to bear any crop at all. In neglected or poorly-cared-for orchards, the intervals between heavy croppings average much longer than in orchards that are cultivated and well cared for.

Not all trees of the same variety may have the 'off' and 'on' years at one time, but every individual tree within the same variety has its own way of bearing fat and lean crops according to its own capacity for manufacturing and accumulating food reserves in its tissues in the preceding season.

Often it happens that the intervals between two periods of heavy flowering may be two years at one time and three to four years for the same tree next time, while an adjoining tree in the same orchard may be flowering and bearing more regularly the fat and lean crops in alternate years. Such a phenomenon would suggest that in the established mango orchards, individual trees keeping subnormal health need special attention with regard to their cultivation.

The most interesting phenomenon of alternate bearing is sometimes presented by a whole group of trees in one orchard alternating with another group in another orchard on the same estate. In such cases the rhythm of alternate bearing between the two orchards is first initiated when in an 'on' year, the flowers of one are destroyed by natural enemies such as pests and diseases and the flowers of the other escape the calamity and set a normal heavy crop.

Still more interesting part of the problem of 'alternate bearing' is the 'alternation' presented by mangoes in one whole geographical part of the country with those in another part. The scarcity or abundance of the crop is not generally the same in all parts of a state. The lean year for the mango in one part, say, the Konkan may be a fat year for the Deccan and *vice versa.* This suggests that the varying weather conditions prevailing throughout the year in different parts of the country have also a profound influence on the fruit-bearing capacity of the trees in that year.

Not all varieties of mango are equally strong in their habit of bearing biennially. It has been observed in Bihar that the varieties that produce mostly terminal inflorescences and only a few axillary types of flower clusters are more markedly biennial bearers, whereas those varieties that produce a greater percentage of axillary inflorescences are moderately regular, annual bearing. Unfortunately, most of our good dessert varieties produce the fewest axillary flower clusters and are, therefore, biennial croppers. Among the few varieties that are known to produce a greater percentage of axillary inflorescences and bear moderate crops every year, *Fazli* of Bihar is a notable example, but most famous of the regular annual bearers are *Nilam* and *Bangalora* of Rayalaseema.

Abundant experience, confirmed by experimental studies in the different parts of India, indicates that the alterante bearing tendency is an inherent varietal characteristic influenced, but not caused, by environmental conditions, such as climate, cultivation, or pests and diseases, which, however, may accentuate or diminish the amplitude of alternation from season to season.

PRACTICAL MEASURES TO OVERCOME ALTERNATE BEARING

It will be clear from the discussion on the various phases of growth in the mango that the tendency to alternate bearing is largely physiological and connected with the changes in the nutritional balance of the tree, and that the alternation is initiated in the 'on' year due to the tree's inability to produce sufficient amount of new vegetative growth in the spring and early summer. It has also been explained that the fluctuations in the nutritional balance occur mostly due to the changes in the weather which is beyond human control, but we can at least cultivate the soil in such a manner so as to maintain the tree in healthy growth and never allow it to suffer from lack of nitrogen. The question is : 'can we make the tree produce sufficient amount of new vegetative growth in spring and early summer when it is profusely flowering and setting fruits ?'

Cultivation. Attempts at forcing substantial amounts of vegetative growth in the spring and early summer of the 'on'

year by ploughing the orchard and manuring and irrigating the tree when it is heavily laden with fruits have, however, met with little success. Some extra vegetative growths can be produced but not to the extent desired. The importance of cultivation in encouraging fruitfulness in the mango, however, cannot be minimised. By giving good cultural treatments annually, we can at least keep the tree reasonably healthy, fit and fruitful in the 'off' years and thus avoid several total failures of crops which usually occur between two heavy croppings.

Experiments carried out at Sabour in Bihar clearly indicate that failure of mango trees to bear heavily for several years and their observance of many 'off' years instead of one is caused by nutritional deficiencies mainly of nitrogen, and that when such trees were given good cultivation and heavy doses of nitrogenous manures annually they revived wonderfully and produced a fair amount of vegetative growth in the spring and early summer even in the 'on' years, and consequently yielded reasonably small crops in the 'off' years. (See recommendations for cultivation, manuring and irrigation in the schedule of annual operations on page 53).

Deblossoming. Some research workers suggest that if half the number of flower clusters are removed from the tree in the 'on' year as soon as they emerge, the food reserves of these deblossomed shoots would be utilized by the tree in producing vegetative growths in spring and summer and the vegetative shoots thus produced would mature and bear a substantial crop in the following year which would otherwise be an 'off' year in the normal circumstances. In other words, this is a device for making the tree moderately fruitful in the 'off' year by sacrificing half the crop of the 'on' year.

Ringing. Ringing of the branches has also been suggested by some research workers as a means of forcing a substantial crop in the 'off' year. The operation of ringing consists in removing a ring of bark, about ¼ inch wide, on a branch about six inches in thickness. The effect of ringing on the branch is the stoppage of vegetative growths and concentration of large amounts of carbohydrates in the portions of the branch above the ring. Thus, the ratio of carbohydrates to nitrogen being raised higher in the branch, the terminal shoots held by it would put forth blossoms instead of vegetative growths during the spring season.

Ringing should be done in August, that is, at least four months before the date of flowering, as this is believed to be the critical period when the buds of the branches differentiate either into vegetative or flower-bearing potentials.

It must be borne in mind that whereas the effect of cultivation and deblossoming practices is to make the tree produce a

fair amount of vegetative growth in the spring of the ' on ' year, the effect of ringing is diametrically opposite. No new vegetative growths are produced as the ratio of nitrogen is lowered, but the existing growths of whatever age and maturity due to rise in the carbohydrate content, blaze out into blossoms in the early spring.

If ringing is done in August after the previous heavy crop of the ' on ' year is harvested, no October-November vegetative growth is possible due to the lowered nitrogen content of the branches, but the already existing terminal shoots that have yielded a heavy crop in June-July put forth another flush of blossom clusters in the following spring. Not all of these exhausted shoots produce blossoms. Only a few of them blossom satisfactorily. These blossoms, however, due to the lowered nitrogen content and the consequent lowered vitality of the branch, generally fail to set fruits and thus the object of turning an ' off ' year into an ' on ' year is not fulfilled by ringing the tree soon after the heavy crop is harvested. Not only this, but such ringed branches especially of old and aged trees get dangerously devitalised and at times dry out in the hot weather.

The ringing of branches in August soon after harvesting a lean crop of the ' off ' year results in a slightly increased quantity of the would-be heavy crop of the following ' on ' year which is, however, not desirable, as intensifying the bearing capacity of the tree in the ' on ' year would mean intensifying the alternate bearing habit of the tree automatically, as we have already seen that the first rhythm of alternate bearing starts with the year of heavy cropping.

It will be realised that ringing does not effect any change in the alternate bearing habit of the mango. On the contrary, it lowers the vitality of the trees that are old and aged. Ringing is, therefore, not recommended for adoption as a regular orchard practice except in special cases such as the forcing of blossoms in an over-vigorous sterile tree (see page 52).

SHY BEARING MANGOES

There are mango varieties which are by nature shy bearers even in ' on ' years. The shy bearing habit of these varieties is due to the fact that most of the flowers in the panicle (flower cluster) are not designed by nature to set fruits.

A panicle may contain several hundreds of tiny yellow flowers of two kinds—male and perfect flowers. The male flowers do not set fruit. It is only the perfect flowers containing both male and female organs that are capable of setting fruit. Even among these perfect flowers, most usually drop off due to various climatic disturbances, leaving about one to three fruits set per

cluster. All varieties are not alike in bearing the proportion of male and perfect flowers in their panicles.

In the panicles of some, like *Alphonso* of Bombay (Ratnagiri), as many as 90 per cent of the flowers are male and only about 10 per cent are perfect. In *Langra* of North India (the Punjab), 66 per cent of the flowers are perfect, while in *Neelam* of South India (Kodur), the percentage of perfect flowers is only 16.

There are varieties like *Alampur Baneshan* and *Jehangir* in which the percentage of perfect flowers is as low as three and one, respectively. This explains why *Alampur Baneshan* and *Jehangir* are known to bear extremely small crops in South India (Kodur) in spite of their habit of producing heavy blossom. It will be seen that the varieties like *Neelam* which are known for their heavy and regular cropping have only 16 per cent perfect flowers and *Alphonso* which is considered a fairly good cropper, only 10 per cent perfect flowers. Thus it may be deduced from these observations that varieties having below 10 per cent perfect flowers are by nature shy bearers.

ALL-THE-YEAR-ROUND CROPPERS

Some varieties called by the group name of *Baramasis* have a natural habit of flowering and cropping at any time of the year, and yield several small crops in different seasons. The vegetative shoots of these varieties do not need long rest for conserving food reserves. The shoots as young as two months old are able to blossom, and even the same terminal shoots that have borne the preceding season's crop can produce blossom clusters from their side buds, immediately after the preceding crop is harvested. None of these *Baramasis* have, however, proved to be dependable off-season croppers or of superior fruit quality. As such, they do not deserve a place in a commercial plantation.

SHRAVANIA MANGOES

As distinct from the common mangoes that flower in the middle or at the end of the winter, there are some seedling trees strewn all over western India which consistently flower as late as March and mature their crops in August (or the month of *Shravana* of the Hindu Vikrama era). In the markets of western India, the mango fruits are rare at this time of the year and, therefore, the fruits of *Shravania* mangoes fetch fancy prices.

OVER-VIGOROUS AND UNDER-NOURISHED STERILE TREES

Some mango trees refuse to flower although of an age to do so. They grow vigorously and only produce vigorous leafy growths for many years after planting. This condition is

due to a very high amount of nitrogen stored in the tissues of the branches as against very low amount of carbohydrates.

Generally, trees growing in rich soils, in half shady situations or receiving abundant irrigation water and excessive quantities of highly nitrogenous manures show these symptoms. Such over-vigorous trees can easily be made fruitful by exposing their crowns to full sunlight, withholding irrigation during the dry seasons and by stopping supplies of nitrogenous manures. Instead, as a remedy, common salt should be given during light rains in September at the rate of five pounds (for trees below 10 years in age), 10 pounds (between 10 and 20 years), and 25 pounds (above 20 years) per tree.

A circular trench one foot wide and one foot deep may be dug under the drip of the tree crown and the salt applied uniformly in the trench and covered with earth. The salt treatment will prevent the tree from putting forth further leafy growth and the previous leafy growth will take rest and will accumulate more carbohydrates for inducing flower bud formation. Consequently, the trees will blossom profusely in January and set a satisfactory crop.

There is another method of forcing blossoms in over-vegetative mango trees. The branches of the tree which are six to nine inches thick, may be girdled or ringed. The operation of girdling consists in removing a strip of bark about half an inch wide all round its base a little above the point where it joins another branch. As a result of girdling, greater quantities of carbohydrates are stored in the portion of the branch above the ring and the nutritional balance of carbohydrates and nitrogen becomes more favourable for producing blossoms.

Girdling should be done in August or early September well before the blossom bud differentiation takes place in the tissues of the tree. Girdling done in October after the winter leafy growths are initiated is not effective in forcing flowering. The operation of girdling is best performed by means of a carpenter's chisel. The width of the ring should not be wider than half an inch. If a wider strip of bark is removed exposing a larger surface of wood, the whole branch above the ring may suffer from lack of water and dry up altogether. Ordinarily, the wound heals rapidly during the early spring after the full flowering of the branch is effected.

Both salt manuring and girdling should only be practised in exceptional and individual cases of over-vigorous trees, especially in heavy rainfall regions. In dry regions with rainfall less than 30 inches the need for practising these methods does not arise, as we seldom find over-vigorous trees in these areas.

Girdling and salt manuring should never be practised on weak trees which are extremely poor in vegetative growth and

refuse to blossom. These trees have already a very high amount of carbohydrates but very little of nitrogen, and when they are girdled or manured with salt the nitrogen content of the branches is still lowered and the nutritional balance becomes still worse for flowering.

Such weakly growing trees with stunted branches and yellow foliagė may be advantageously treated with highly nitrogenous manures in the early spring or in the beginning of the monsoon to enable them to put forth more vegetative growths, which would improve in their nitrogen content and become blossom-bearing shoots later.

SCHEDULE OF ANNUAL OPERATIONS

The following schedule of annual operations is recommended as an aid to successful cropping of mangoes:

(1) After the last crop is harvested, dead and diseased branches and the *Loranthus* parasite should be cut off clean with a hand-saw or a sharp sécateur and the big wounds painted with tar.

(2) Examine the trunks for stem-borers and the branches for red ant nests and destroy these insects. Destroy the mango shoot-borers if you find them boring the top shoots of young grafts by spraying with DDT 'Guesarol' 550 (1 in 20). (See details on pages 61 and 62).

(3) In humid regions, remove lichens, moss and sooty mould from branches by scrubbing them with coir rope or some other rough material.

(4) Plough and harrow the orchard or dig the soil with hand at least twice in the year. In the beginning of the monsoon after harvest and at the end of the monsoon in October, always keep the land free of weeds by frequent harrowings.

(5) In young orchards where it is intended to take cold weather inter-crops, sow sannhemp in the open space left between the trees in June and bury it as green manure in the beginning or in the middle of August.

(6) In old orchards where all the orchard space is practically covered and no green manure crops or inter-crops can be grown, spread about 10 cartloads of farmyard manure per acre in the beginning of the monsoon and mix it well by harrowing. Manure individual trees with special manures in the beginning of the monsoon in the light rainfall

areas and near the end of the monsoon in the heavy rainfall tracts.

Where water-soluble artificial manures like ammonium sulphate are given, it is necessary that the operation of manuring be followed by a very light irrigation or light rainfall.

(7) In North India, protect the young newly-planted plants against frost in winter by covering them on three sides and the top with thatch.

(8) Dust a mixture of DDT and finely ground sulphur ('Guesarol' 405-50 contains five per cent DDT and 50 per cent sulphur in a finely ground form) on the flowers as soon as they emerge, and give two more dustings at intervals of 15 days as a preventive against the attacks of mango hoppers and powdery mildew which usually destroy the mango blossoms in all parts of India.

(9) Remove abnormal or malformed inflorescences, if any, and burn them.

(10) Keep the young orchard always well protected from the ill effects of hot or violent winds by planting a permanent wind-break on the windward side.

(11) Irrigate young trees at regular intervals during the dry seasons, especially during summer.

(12) In North India, the soil around the newly-planted young grafts may be soaked with 0.2 per cent DDT suspension occasionally to kill white ants. Mixing castor or *neem* cake in irrigation water may also help in keeping off white ants.

YIELD

The grafted tree begins to bear from its fourth year producing 10 to 15 fruits in its first bearing season. This number increases to 50 to 75 in its sixth year and to 300 to 500 in its 10th year from planting, provided the soil and cultivation are good and the climate congenial. In some of the well-cared for orchards in Ratnagiri, *Alphonso* in its 10th to 15th year has yielded, on an average, about 1,000 fruits, in 15th to the 20th year about 1,500 fruits and from the 20th year onwards 2,000 to 5,000 fruits.

In general, with trees in full bearing and of about 20 to 40 years in age, a crop of 1,000 to 3,000 fruits in 'on' years may be considered good for any grafted variety which is known as a good cropper in any part of India. The prolific years are ordi-

narily from the 10th to 40th year. After this age, the yield begins to decline. Seedling mangoes live longer than grafted trees and bear much heavier crops. In fairly favourable situations and in an 'on' year, a 60 to 70-year old tree is often reported to yield over 10,000 fruits in the Bombay Deccan and also in many parts of South India.

The above yields per tree are quoted here for the trees situated in the most favourable environments and receiving the best of cultivation and treatment against pests and diseases.

HARVESTING

The mango takes five to six months from flowering to mature its fruits. The whole tree does not flower all at once but different branches flower at different times, in several distinct flushes lasting over a month. In Bombay and in the neighbourhood of Ratnagiri, the mango harvest is nearly over by the end of May except for a few late varieties, whereas in the Bombay Deccan and South Gujerat where the flowering occurs in January-February, the harvest begins from the middle of May and continues till the end of June. Similarly, in South India, the main harvest season opens with Malabar mangoes in February or March depending on the season, and is at its height there in April and May. In the coastal Andhra, it is April to July, and in Rayalaseema and Mysore it extends over a long period of four months from May to August. In Bihar and Uttar Pradesh and other parts of North India, the harvesting season begins from early June to late in August.

The mature mango fruits are plucked from the tree when they are yet hard and green but before they have changed colour and ripened. If left on the tree till they ripen, they would be spoiled by crows, parrots, etc. and would not keep for long in storage. It is generally believed that when a few semi-ripe fruits begin to fall naturally from the tree, the whole crop of fruits on that tree is mature enough for picking and thus growers often prefer to harvest the whole crop of a tree at one time for reasons of economy. But it must be borne in mind that all the fruits on a tree cannot be of the same degree of maturity. Those that set from the first flush of flowers are more mature than those from the second; the fruits from the third flush of flowers have rarely reached the optimum maturity indicated by the fruits of the first flush. Thus, if the fruits of all the three flushes are harvested together at one time, especially early in the mango ripening season, there is every danger of picking some immature fruits which may not ripen properly later in storage. This is particularly true in the case of off-season cropping varieties cultivated in the Tamilnad and certain other parts of South India, which have quite a long flowering season.

Though the change of colour from green to yellow and softness of the skin are the apparent signs of full maturity, one cannot afford to wait for the extreme stage of maturity, as soft fruits would not keep long after picking and as such cannot be exported to distant markets. Even for local markets, the fruits should be green and hard for handling in trade. Experienced growers have a knack of spotting a mature fruit. In the *Alphonso* and *Pairi* varieties, a fruit is taken as fully mature when its sides have swollen and its 'shoulders' have outgrown the stem-end. Besides, the colour of the mature fruit is blue green or pale green as against the dark green of an immature fruit. Similarly, in other varieties colour shades of different intensity may be observed at the time of approach to full maturity.

One has to climb a mango tree to harvest its fruits. The mature fruits should be very carefully picked one by one without bruising by means of a bamboo pole harvester. This is a handy instrument made of a long bamboo pole to the end of which is fixed a small net bag hanging loose from an iron ring about 12 inches in diameter with knife blades thereon to sever the fruit stalk. The fruit after being severed by the iron blades falls into the net bag. A few more fruits are similarly plucked one by one and collected in the net bag. The pole harvester is then lowered and the contents of the bag emptied into a sac (made from fisherman's net) which is held and tied on the lower branches of the tree. This sac is capable of holding 200 to 300 fruits. When this becomes full, it is lowered to the ground. The fruits are then temporarily heaped underneath the tree on a bed of green mango leaves.

RIPENING

After picking, the fruits are transferred to a store-house for ripening. The fruits are first spread in one layer on a bed of mango leaves and left there exposed for about two days. They are then transferred to rice straw for ripening. The store-house, though closed, should be well ventilated and not completely dark. The straw is spread three to four inches thick on the floor of the house and the fruits are arranged over it in single layers. Two or three such layers are built up one above the other, separated by two inches of straw.

Rice straw is preferred to any other grass for ripening mangoes as it causes uniform ripening and good colouration. Besides, it is soft and there is no danger of marking or bruising which usually causes rotting of the ripening fruits. Fruits thus kept in straw may change colour, turn yellow and become slightly soft. The whole lot is then taken out for immediate sale. After this, the fruits slowly develop their characteristic varietal colour at ordinary room temperature.

PACKING

If mangoes have to be sent to distant markets for sale, they should be graded in different sizes immediately after picking when they are hard and green. Each grade is then separately packed in a suitable container and duly labelled. The label should indicate the variety, size and number of fruits, and the address of the consignee.

Usually, cylindrical bamboo baskets are used for packing mangoes all over India, but these containers are not entirely satisfactory as they are badly handled in transit on railways or ships while loading and unloading. Wooden crates are better for packing superior varieties as they are more carefully handled. A ventilated wooden crate of the size 2 foot × 1 foot × 1 foot which can hold about a hundred individual fruits, has been found to be quite suitable for trading in the *Alphonso* mango in Bombay State.

Rice straw or any kind of soft dry grass is excellent for padding around the fruits inside the package. The fruits must be packed tight in the package. It should, however, be borne in mind that the use of excessive quantities of packing material adversely affects the quality of the fruit. Hence, only a light wadding of packing material should be used to hold the individual fruits in position and to minimise bruising.

For export of mangoes to foreign countries a small crate of the size 18 inches × 10 inches × 4½ inches holding one dozen fruits in a single layer has been found to be most suitable for keeping in cold storage on the ship. Each individual fruit should be wrapped in tissue paper and packed in sufficient wood wool to keep the fruit in position in the crate.

The suitability of a mango variety for interprovincial trade chiefly depends upon its keeping quality, i.e., its ability to remain wholesome after ripening. Most of the famous dessert varieties do not keep for more than a week after ripening but there are exceptions like *Alphonso* of Bombay which keeps in wholesome condition for about two weeks after ripening and *Bangalora* of South India which keeps for about four weeks. *Bangalora* is said to be so hardy that, while sending it to western and North India markets by rail, it is not packed in baskets or crates but is loaded as such in railway wagons.

COLD STORAGE

The mango is a highly perishable fruit and some of the best varieties are available only for a short while in the market. Besides, when the crop is heavy, the market remains glutted with fruits which have to be sold away cheaply well before they begin to spoil. To avoid extremely low prices resulting from gluts and also to lengthen the season of

availability of mangoes, their preservation in cold storage is recommended.

In cold storage, fruits can be preserved in their original freshness for days and months together. The cold store is an insulated house in which the cooling of air is effected by a process called the ammonia-brine circulation system. In the cold store, different rooms with different temperatures are provided to store different kinds of perishable commodities such as fruits, vegetables, meat and fish. Such cold storage facilities are already available in a number of larger cities. Also, every big passenger ship nowadays is equipped with a cold store for carrying fresh fruits from one country to another.

Freshly plucked, green mangoes can be sent to such cold storages carefully packed in small crates. A large part of the best fruit could be promptly withdrawn from the market at the harvest time when a glut is feared. In this way the prices of good fruits are less likely to be depressed. The fruits can then slowly be released from the cold storage as and when required to meet the demand of the market, and can be sold at reasonably high prices during the periods of scarcity. By means of cold storage, mangoes can also be successfully shipped to foreign countries which do not involve a journey of more than a month.

Practically all the known dessert varieties of mango grown in different mango-growing regions of India, such as *Alphonso* and *Pairi* of Bombay, *Langra* and *Zardalu* of Bihar, *Fazli* and *Dasheri* of Uttar Pradesh and *Suvaranrekha*, *Banganpalle* and *Jehangir* of Madras were experimented with under varying cold storage conditions at the Ganeshkhind Fruit Experiment Station, Poona.

Of all the varieties tested, the fruit of the *Alphonso* variety was found to be the best keeper in cold storage. Fully mature, hard and green fruits can be preserved in a satisfactory condition at 45° to 48° F for seven weeks, and can subsequently be fully ripened at ordinary room temperatures. A temperature lower than 45° F injures the green fruit which does not ripen properly when removed to ordinary room temperatures. Ripe yellow fruit, however, cannot be preserved in good condition in cold storage as it turns brown and gets pitted all over the skin.

INSECT PESTS AND DISEASES

THE mango, when in blossom, suffers from an important pest, the jassid hopper, and the disease known as powdery mildew in most of the mango growing regions of India.

The jassid hopper. The mango hopper is a small, wedge-shaped insect belonging to the class of bugs. As soon as the blossoms appear, these tiny insects lay their eggs inside the bud tissue, which hatch in four to six days. The small wingless nymphs which emerge from the eggs suck the sap from the flowers and tender fruits and develop into winged adults in 10 to 12 days after casting four moults. The continuous drain of the sap by the nymphs as well as the adults leads to the premature dropping of flowers and young fruits. Besides, these insects are capable of secreting large quantities of sticky honeydew which covers the flowers and thus interferes with their fertilization.

The characteristic blackness of the flowers and leaves in the affected gardens is due to the development of a black sooty mould on the sugary secretion. The winged adults are found resting on the stems and leaves, and, when disturbed, they jump and fly off to the neighbouring leaves causing a peculiar spattering noise which can be heard from a distance. The hoppers are capable of destroying the whole crop, but the loss usually varies from 25 to 60 per cent.

Powdery mildew. Powdery mildew is easily distinguished by the whitish appearance of the affected blossoms which appear as if dusted with fine white flour. The mildew makes its first appearance on the scales and tip-buds of tender flower heads, and then gradually extends downwards along the flower axis and stalk. The minute spores (seeds) of the fungus are carried away by wind from the affected flower heads to the hairy unopened flowers, which become diseased and produce spores within five days from the time of infection. The process of spore formation and secondary spread continues as long as conditions are favourable during the season. It can thus be seen how a few affected flower heads can cause widespread infection under favourable conditions.

The white appearance of the diseased blossoms is due to the thick covering of spores and mycelium or the vegetative parts of the fungus. The fungus feeds on the outer cells of flowers and very young fruits, which consequently dry up and drop down. Powdery mildew, though not as destructive as the hoppers, may cause a loss of 5 to 20 per cent, mostly during the months of February and March.

The most effective remedy for both mango hoppers and powdery mildew is a mixture of DDT dust and finely ground sulphur (325 mesh). 'Guesarol' 405-50 is a ready-made product containing DDT and sulphur in the required proportions, i.e., five per cent DDT and 50 per cent sulphur. If this mixture is dusted by means of a dust gun on the flower clusters soon after their emergence about three times at inter-

vals of 15 days, both the hoppers and mildew can be very effectively controlled.

DDT kills the hoppers outright and sulphur is a preventive and curative against mildew. If the DDT dust is not avilable, dusting the trees with finely ground sulphur (325 mesh) alone would help in warding off the attack of the hoppers to a very large extent. The odour of sulphur drives away the adult insects and prevents them from laying eggs on the flowering branches. Even in bad cases of hopper infection, nymphs gradually drop off within three to four days of sulphuring and flowers are left quite free of them.

While the use of sulphur alone in dusting mango trees is safely recommended the grower is warned against the use of the DDT dust alone. DDT alone no doubt kills the mango hoppers effectively but at the same time fosters the appearance of another insect pest called mites which cannot be killed by DDT alone.

Mites are very minute insects not visible to the naked eye. They are always present in small numbers on the trees and are usually controlled and kept in check by other kinds of predatory insects which feed on them. That is why we do not usually find mites as a pest on mango. But when we dust the mango trees with DDT alone, the predatory insects are also killed along with the hoppers and thus in the absence of predatory insects, mites increase in great numbers and immediately attack the leaves and flowers which become silvery white, dry up and drop down. Sulphur is the best remedy for mites also and, therefore, it should invariably be mixed with DDT for dusting mango trees.

The best method of dusting is by means of an efficient duster. The best known crank duster available in India before the Second World War was the 'Peerless Dust Gun'. With this duster, it is possible to dust trees 12 to 15 feet in height ; for larger trees the use of a step-ladder will be found very convenient. An equally efficient dust gun of a similar construction is now made in India.

The trees may be dusted at any time of the day. Dusting in high wind results in waste of material, but a gentle breeze helps the operation. However, still days are the best. Normally, about two pounds of the dust mixture are required to dust a tree about 25 feet in height. Larger trees may require about three pounds for one application. If untimely rain washes off the dust before there have been three or four days of sunshine, dusting must be repeated.

In dusting mango trees care should be exercised to operate the duster with the back to the wind, as the DDT-

sulphur mixture would cause irritation to the eyes. It is better that the operator wears a pair of goggles. If the eyes become inflamed, immediate relief may be obtained by bathing the eyes in a solution of a teaspoonful of soda biçarbonate (baking soda) in a large glass of water.

Mango stem-borer. It is generally found on old mango trees throughout India. It is a stout, thick grub of a large beetle. The beetle lays eggs in chinks of the rough bark of the trunk and massive branches. The young grub or the borer, on emerging from the egg, makes straight, zigzag or spiral tunnels in the bark and feeds on the live tissue of the inner bark. Badly infested branches get completely girdled and die a lingering death, and it is not uncommon to find huge trees drying due to neglect in controlling this pest.

The presence of the borer can be easily detected by tapping the bark with a piece of wood. The affected part gives a hollow sound, and often sawdust-like, chewed fibres thrust out by the insect through a crack in the bark can be seen collected on the ground at the bottom of the trunk. The borer can be traced by cutting the dead bark along the hollow tunnels by means of a stout knife, or it can be killed by thrusting a stiff wire into the tunnel. Where the borer has entered the wood and, therefore, cannot be traced, the hole may be plugged with a wad of cotton wool dipped in kerosene and plastered with wet mud. The borer will thus get suffocated and die within the tree.

Sanitary measures in the orchard, such as removing all dead branches of the tree and burning them and not allowing the dead infested trees to exist in the orchard, will go a long way in controlling this insect.

Shoot-boring caterpillar. It is a major pest particularly of mango seedlings in a nursery or young orchard trees. The caterpillars bore into the growing young shoots from July to December. As a result of the attack of these caterpillars, the shoots wither and die. Spray 0·2 per cent DDT water suspension made from 'Guesarol' 550 wettable powder mixed with wettable sulphur in the ratio of one pound of 'Guesarol' 550, three pounds of wettable sulphur and 30 gallons of water. Spray twice at intervals of three weeks when there is no rain. Clip the dead shoots and burn them.

Shoot-webbing caterpillar. A number of caterpillars are found to bind the leaves at the end of a branch into a close nest-like formation inside which they feed. They are brown caterpillars with grey lateral stripes. Wherever such nests are found, they should be cut and collected in a bag and afterwards destroyed by fire. In the case of a strong infestation,

spraying with 0·2 per cent DDT as prescribed for the shoot-boring caterpillars will do considerable good.

Fruit fly. This is a pest of the ripening mango fruits. It is almost the size of the common house fly. It can be easily distinguished from the ordinary fly by its triangular-shaped abdomen and spotted wings. The fly lays eggs under the rind of the fruit when it is about to ripen. Within a few days, the eggs hatch and young white maggots or worms start feeding deep into the soft pulp. The affected fruits drop on the ground and the maggots pupate in the soil and emerge as flies after a week or 10 days. So generations after generations of these flies persist in the orchard. In the case of delayed harvesting, the entire crop on the tree would thus be spoiled and rendered unmarketable.

Fruit fly control consists in preventive measures only. Semi-ripe, bird-pecked fruits naturally falling from a tree at harvest time should never be allowed to lie underneath the tree and rot. They should be burnt and destroyed as they usually contain the maggots of the fly. Green, hard fruits are never attacked by fruit flies. The mature fruits in their green hard stage should, therefore, be promptly harvested and marketed at once or ripened artificially in storage.

Mango stone weevil. This is a small weevil attacking the mango fruits when they are very small. The weevil lays eggs on the skin of the newly-set pea-like young fruit. The tiny grub of the weevil emerging from the egg finds its way to the centre of the fruit and the insect passes through all the stages of its growth inside the stone. When the fruit is ripe and ready for the table the weevil may burrow its way out of the stone. Discolouration of the pulp adjacent to the stone due to its excreta being thrust out through a hole is very often seen when such mangoes are cut. The insect appears to be partial to certain varieties of mango only. For instance, *Bangalora* of Madras imported into Bombay under the name of *Totapuri* is generally found to be affected by this insect.

Red ants (Oecophylla smaragdina). These are big, red-coloured ants. They build leaf nests on the tree and move about in long trains all over the branches and on the ground of the mango orchard. They are active throughout the year. They do not cause injury to the tree but act as distributing agents of other injurious scale insects. They also cause much annoyance by stinging the people working in the orchard. Red ants can easily be destroyed by dusting a mixture of 'Gammexane' (five per cent BHC) with sulphur in the proportion of 2:1.

Anthracnose. This is a fungoid disease mostly prevalent in the moist tropics, such as the Tamilnad, Travancore-Cochin and Assam. It mostly attacks the tender portions of the mango tree, such as young leaves, stems, flowers and fruits. Dark, blister-like spots apear on the young twigs and leaves. The blossoms turn bleak, dry up and fall. The attack becomes especially serious if untimely rains occur during the flowering period. Fruits of all ages may be infected and young fruits may shed. Black spots also develop on older fruits and these increase as maturity approaches. The skin of mature fruits get badly disfigured by the black spots. The pulp beneath the spots usually becomes hard in texture. The disease causes an unsightly appearance and leads to rapid decay of the fruits at the time of ripening, thus lowering their price and often making them unfit for consumption.

The disease can be effectively controlled by spraying Bordeaux mixture (3-3-5) two or three times within two weeks before the blossoms open and also at intervals of three or four months during other dry periods of the year. The Department of Agriculture in Assam recommends spraying of Bordeaux mixture three times in a year: February, April and September. All diseased and dead branches of the tree which usually carry spores of the fungus should be promptly removed and burnt. Bordeaux mixture is prepared as follows:

Dissolve three pounds of copper sulphate crystals in four gallons of hot water in a wooden tub. Then add enough cold water to make 40 gallons. In another container, place five pounds of quicklime of good quality (never use air-slaked lime) and add enough water to nearly cover it. After the lime is slaked, add enough water to make up 10 gallons.

Now slowly pour the copper sulphate solution into the milk of lime, and stir thoroughly. After the whole of copper sulphate solution has been poured into the lime suspension and stirred vigorously, Bordeaux mixture is prepared and is ready for use.

Test the Mixture by dipping the shining blade of a knife in it for some time. If no copper deposit is left on the blade, the mixture is good, but if a deposit is left and the knife blade turns reddish, add more lime to the mixture till the knife shows no such deposit.

Bordeaux mixture should be applied fresh, immediately after preparation, but in no case later than three hours after it has been made. Bordeaux mixture attacks iron and, therefore, should never be kept in an iron container. Before filling the sprayer, the mixture is strained through a wire strainer.

Black tip or mango necrosis. This is a disease of the fruit only. As the fruits approach maturity their tips become

prematurely pulpy and develop large, dark brown spots which gradually harden. This disease is reported to be occurring in the mango orchards in the vicinity of brick-kilns in Bengal, Bihar and Uttar Pradesh. The maximum distance from the brick-kilns at which damage is observed in 700 yards. It seems some poisonous ingredients of the fumes of the brick-kilns cause the black-tip disease. There is no remedy except to avoid planting of new mango orchards within a mile of a brick-kiln. For orchards in the close vicinity of brick-kilns, much relief can be obtained by raising the chimneys at least 50 feet, or by not operating the kilns from the beginning of March through the mango fruiting season.

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